Section 13.0 <u>QUANTIFICATION OF CHANGES IN EMISSIONS</u>

This section presents various comparisons of emission estimates as calculated by MVEI7G and EMFAC2000. These comparisons explain which factors, i.e., changes in population estimates, vehicle miles traveled, basic emission rates or other correction factors, account for changes in emission estimates between MVEI7G and EMFAC2000. These comparisons are made for summer (ozone) inventories for the South Coast Air Basin (SCAB) for calendar years 1980-2010, in five year increments.

13.1 <u>Baseline Comparisons</u>

Figures 13-1, 13-2, 13-3 and 13-4 show comparisons of the total running exhaust TOG, CO, NOx and PM emissions in tons per day, respectively. Each figure shows the percent change in VMT and pollutant relative to MVEI7G estimates. These figures show that there are large increases in running exhaust emissions attributable to changes in vehicle activity (population, mileage accrual), basic emission rates, speed/cycle correction factors, effectiveness of previous I/M programs and the inclusion of relative humidity NOx correction factors, and air conditioning correction factors.

Figure 13-1 <u>Comparison of Total TOG Running Exhaust (tpd)</u>

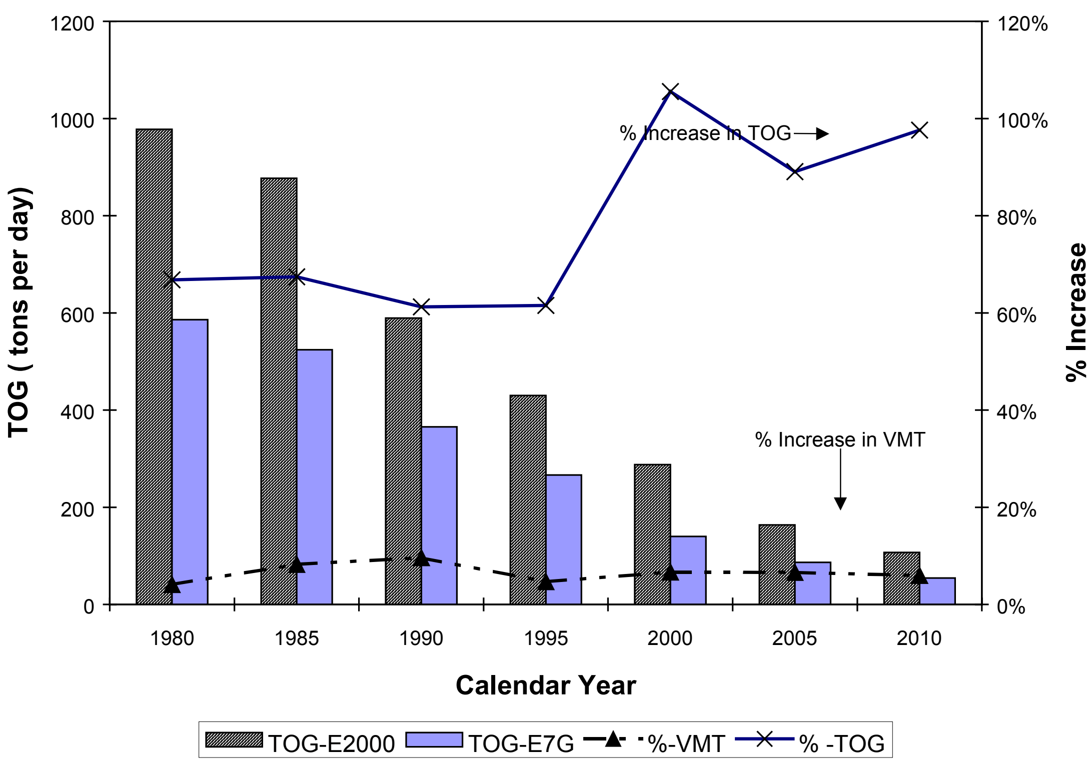


Figure 13-2 Comparison of Total CO Exhaust (tpd)

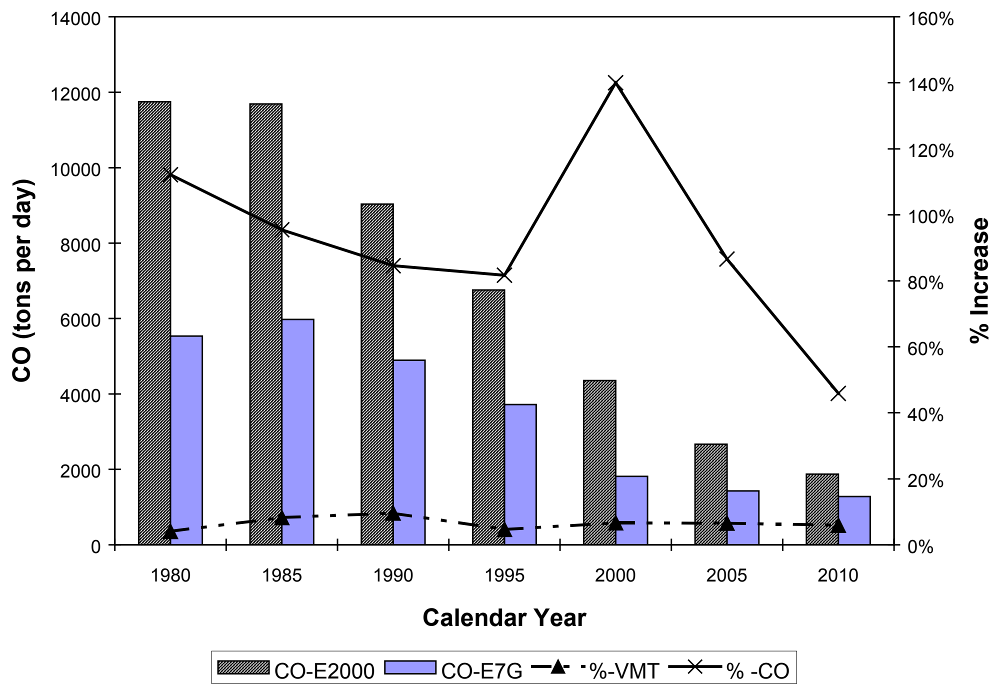


Figure 13-3 Comparison of Total NOx Exhaust (tpd)

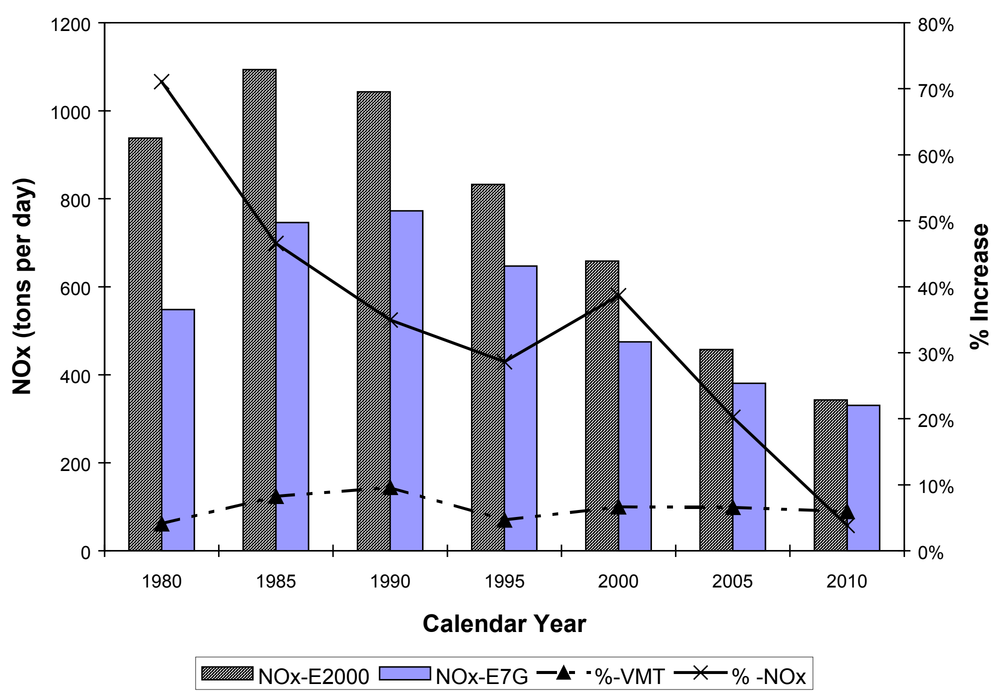
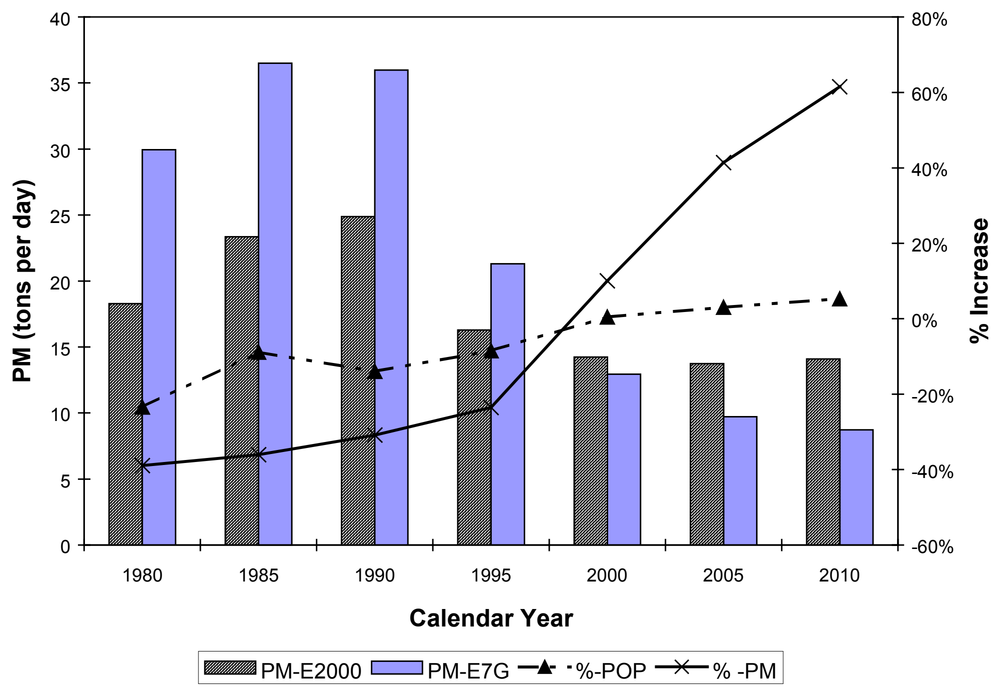


Figure 13-4 <u>Comparison of Total PM Exhaust (tpd)</u>



Figures 13-5, 13-6, 13-7, 13-8 show the total running exhaust TOG, CO, NOx and PM emissions in grams per mile, respectively. These comparisons partially mitigate the differences in vehicle activity between EMFAC2000 and MVEI7G, however, these comparisons do not reflect differences in the average age of the composite vehicle between the models. The redistribution of vehicles in EMFAC2000 results in an increase of the average age of the fleet. Section 7.2[1] details how the average of the fleet has changed between MVEI7G and EMFAC2000.

Figure 13-5 shows that TOG increases by 47 to 93 percent over MVEI7G's estimates. Figure 13-6 shows that CO increases by 38 to 125 percent. For both TOG and CO the change in the percentages by calendar also reflect differences in how fleet wide emissions are dropping in each model. Figure 13-7 shows that NOx changes by –2 to 64 percent. The EMFAC2000 model predicts a higher inventory for NOx for pre 2005 calendar years, however, the NOx is basically the same as MVEI7G for CY 2010. Figure 13-8 shows that PM changes between –41 to 53 percent. MVEI7G estimates for PM are higher that EMFAC2000 estimates for pre 2000 calendar years. However, the MVEI7G PM estimates decrease at a much faster rate than EMFAC2000, hence the increase in PM estimates for 2000 and later calendar years.

[1] Section 7.2 County-Specific Vehicle Age Distribution and Population Matrices

Figure 13-5 Comparison of Total TOG Running Exhaust (g/mi)

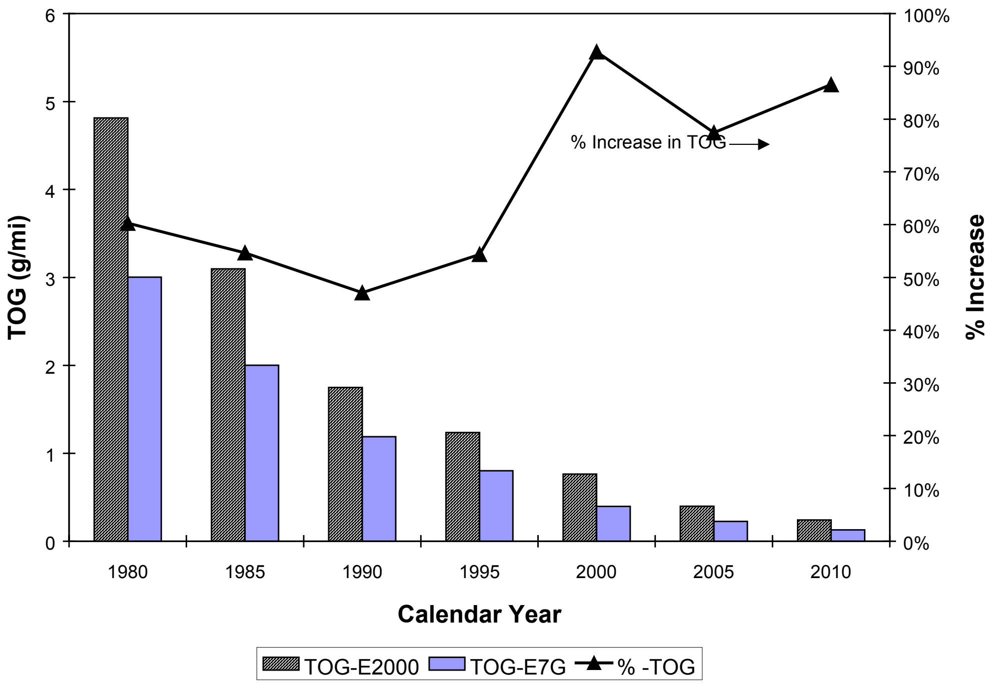


Figure 13-6 Comparison of Total CO Emissions (g/mi)

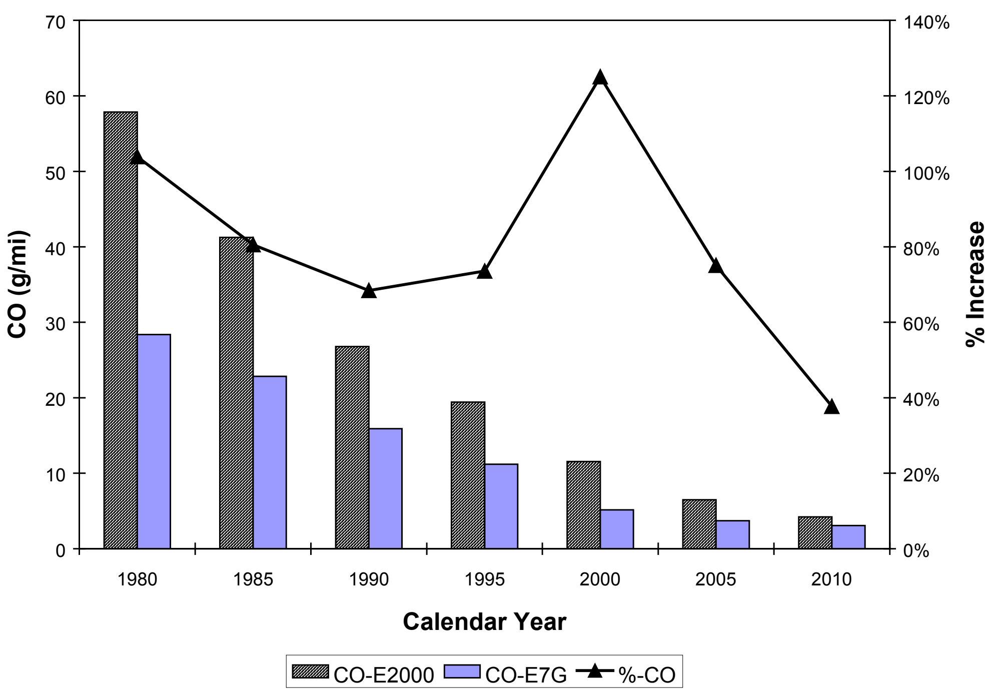


Figure 13-7 Comparison of Total NOx-Exhaust (g/mi)

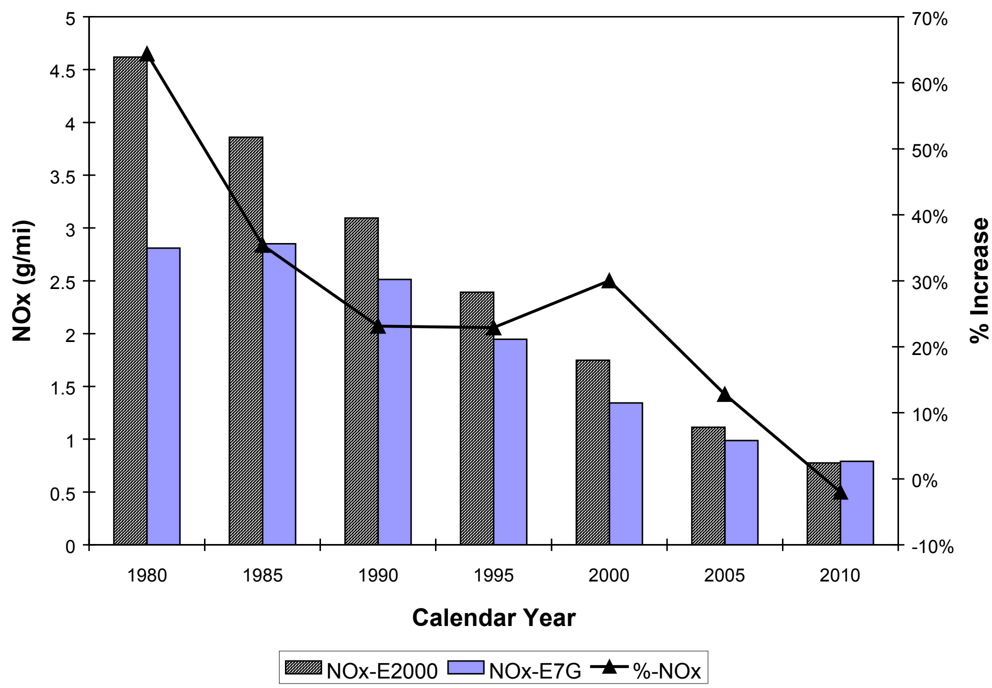
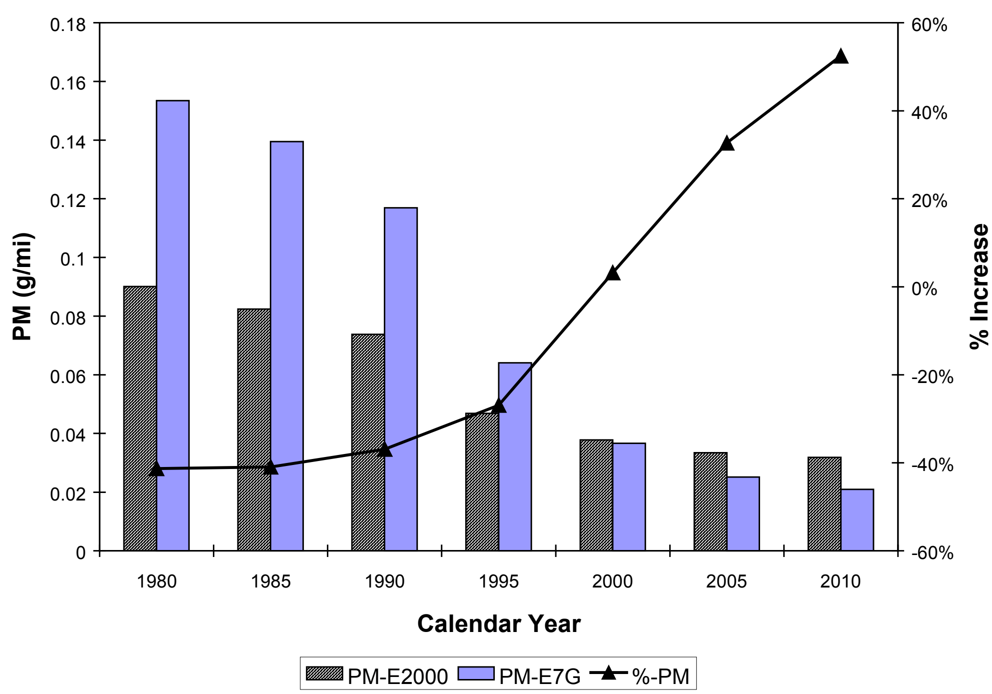


Figure 13-8 Comparison of Total PM-Exhaust (g/mi)



13.2 Comparisons with No Correction Factors

In the following comparisons the MVEI7G was run assuming that there was no changes in the fuel correction factors (due to the introduction of Phase 1 and Phase 2 fuel) and that there is no inspection and maintenance program. The EMFAC2000 program was also run under similar conditions. Both models only include the effect of temperature on emissions, and emission estimates are on an FTP basis. This comparison insulates the emission comparisons from the effect of other correction factors, and shows the change in basic emission rates between the models. Figures 13-9, 13-10, 13-11and 13-12 show the running exhaust tons per day comparisons between MVEI7G and EMFAC2000 for TOG, CO, NOx and PM, respectively. Each figure shows the percent change in VMT and pollutant over MVEI7G's estimates. Figures 13-13, 13-14, 13-15, 13-16, show the gram per mile comparisons between EMFAC2000 and MVEI7G for TOG, CO, NOx and PM, respectively.

Figure 13.9 Comparison of Total TOG Exhaust (tpd)

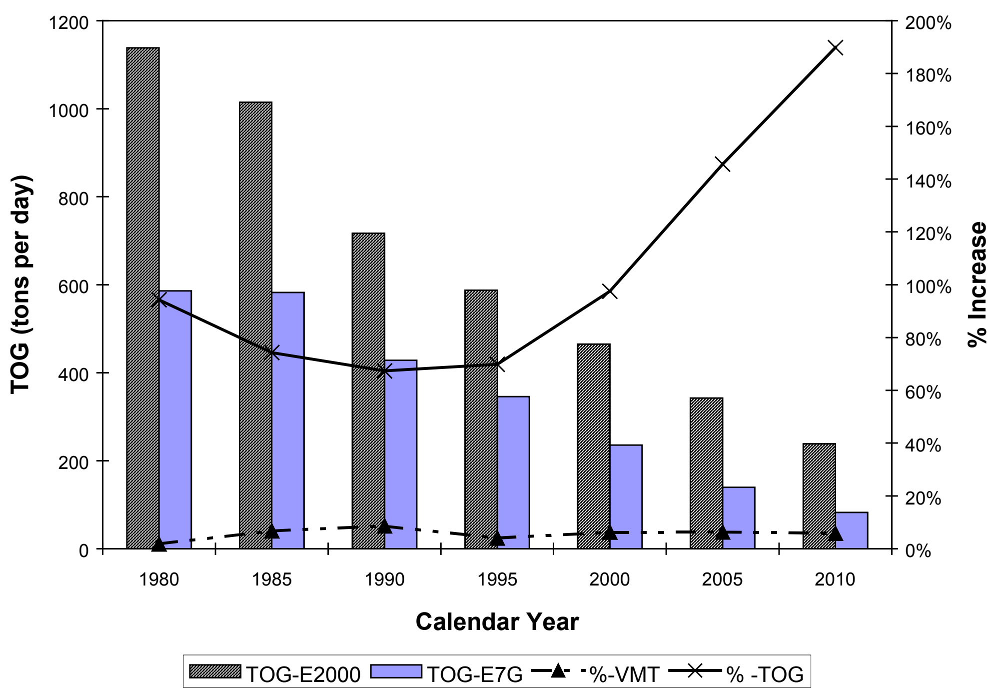


Figure 13-10 Comparison of Total CO Exhaust (tpd)

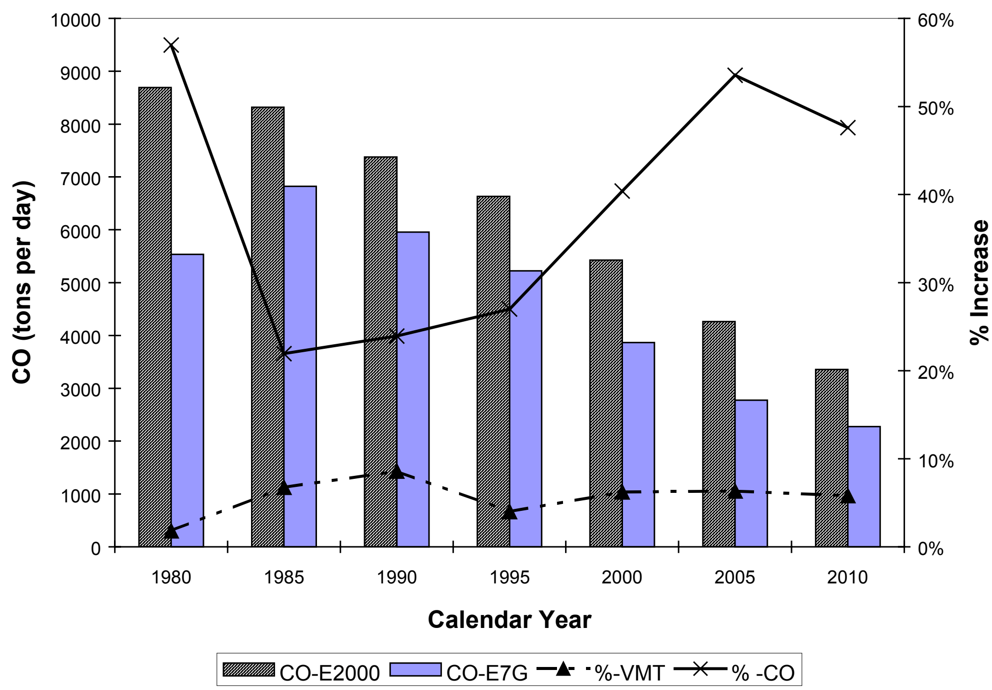


Figure 13-11 Comparison of Total NOx Exhaust (tpd)

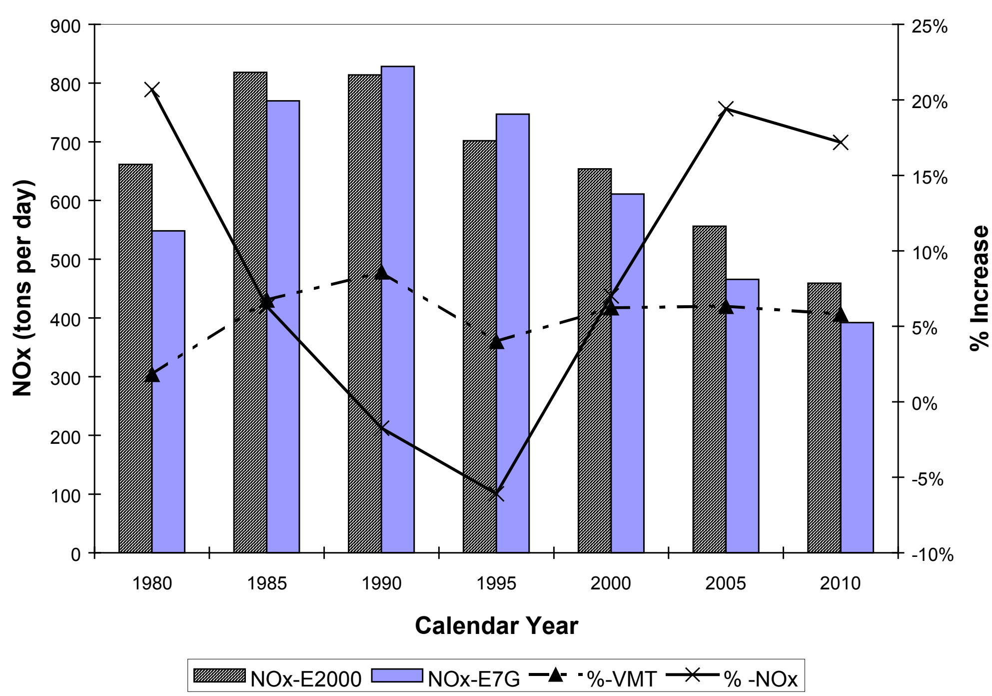


Figure 13-12 <u>Comparison of Total PM Exhaust (tpd)</u>

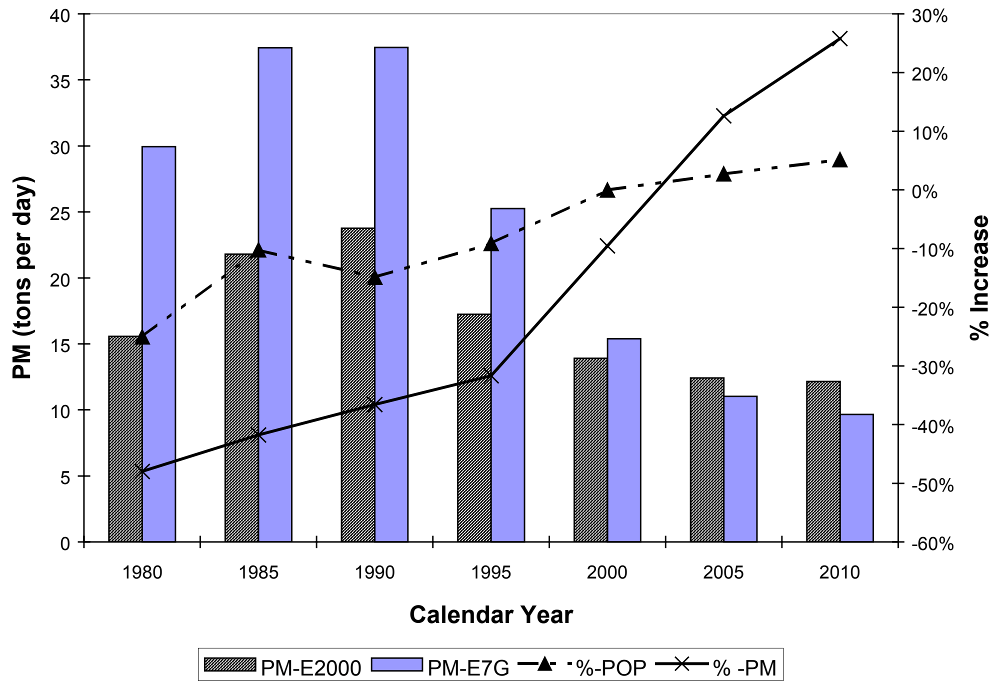


Figure 13-13 <u>Comparison of Total TOG (g/mi)</u>

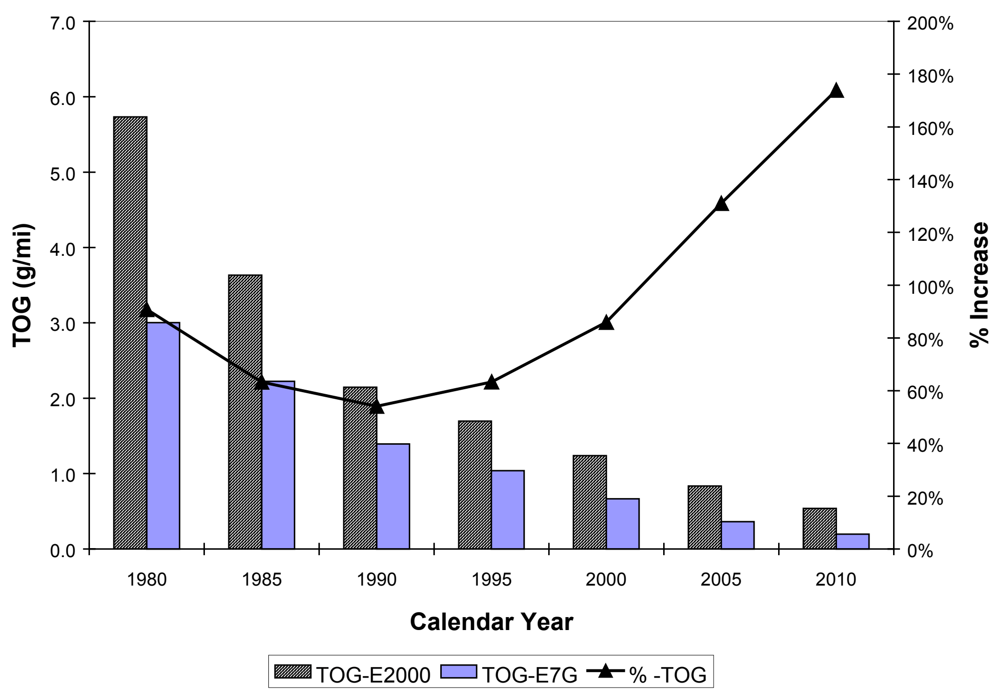


Figure 13-14 Comparison of Total CO Exhaust (g/mi)

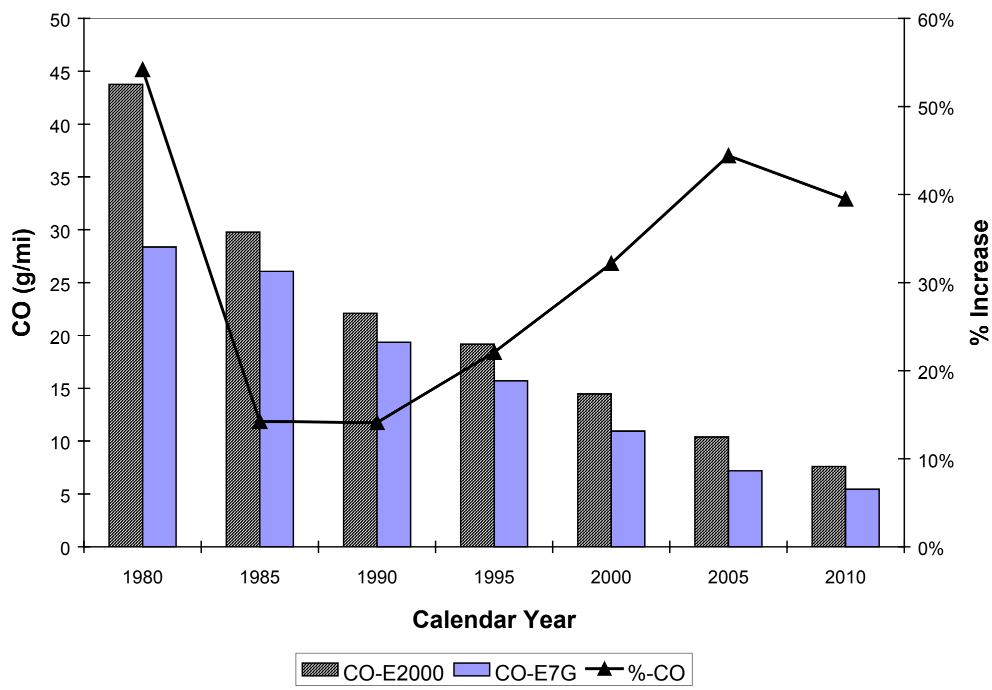


Figure 13-15 Comparison of Total NOx Exhaust (g/mi)

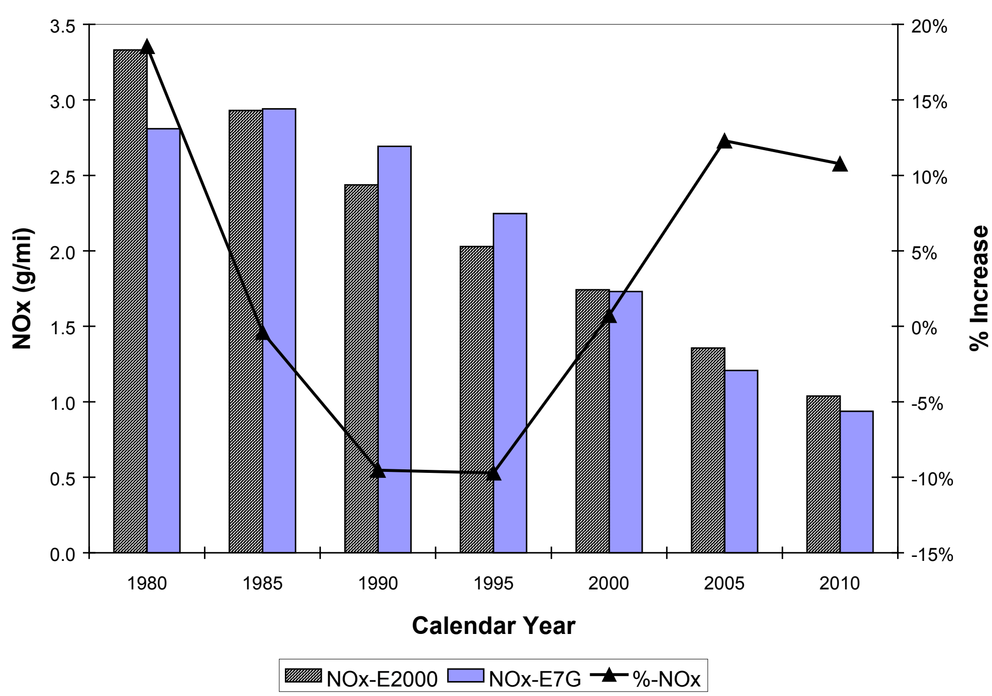
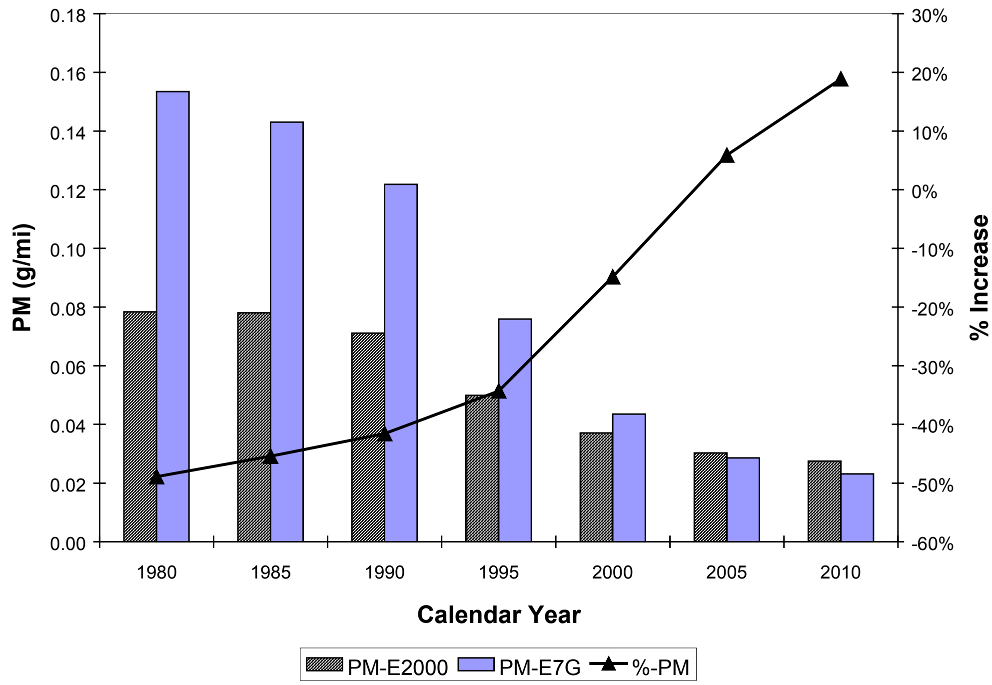


Figure 13-16 Comparison of Total PM Exhaust (g/mi)



13.3 Effect of Chronically Unregistered Vehicles

Chronically unregistered vehicles are 0.57% of the overall vehicle population (see Section 7.2) in any given calendar year. Figures 13-17, 13-18, 13-19 and 13-20 show the effect of chronically unregistered vehicles on the total running exhaust emissions of TOG, CO, NOx and PM, respectively. Accounting for unregistered vehicles increases the inventory by approximately 1-2 percent.

Figure13-17 Effect of Chronically Unregistered Vehicles On Total TOG Running Exhaust Emissions

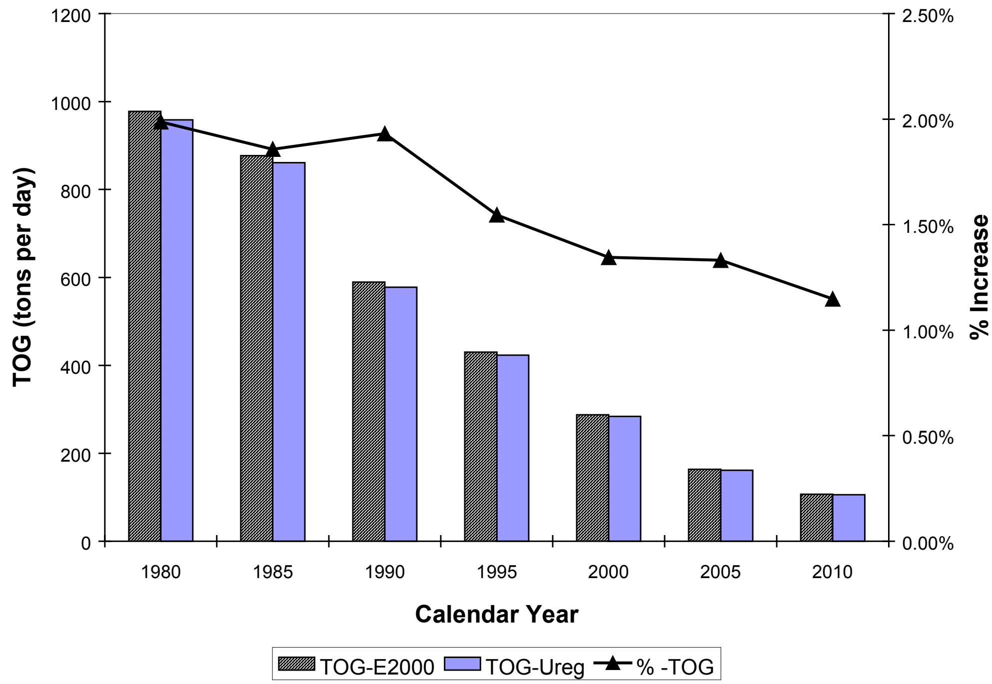


Figure 13-18 Effect of Unregistered Vehicles on Total CO Running Exhaust Emissions

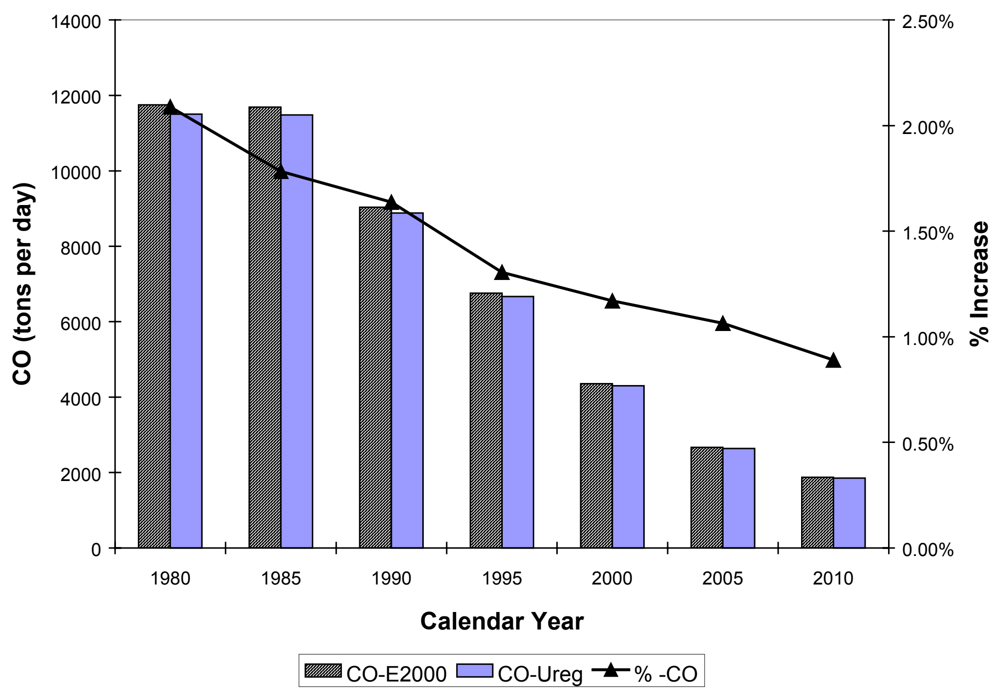


Figure 13-19 Effect of Unregistered Vehicles on Total NOx Running Exhaust Emissions

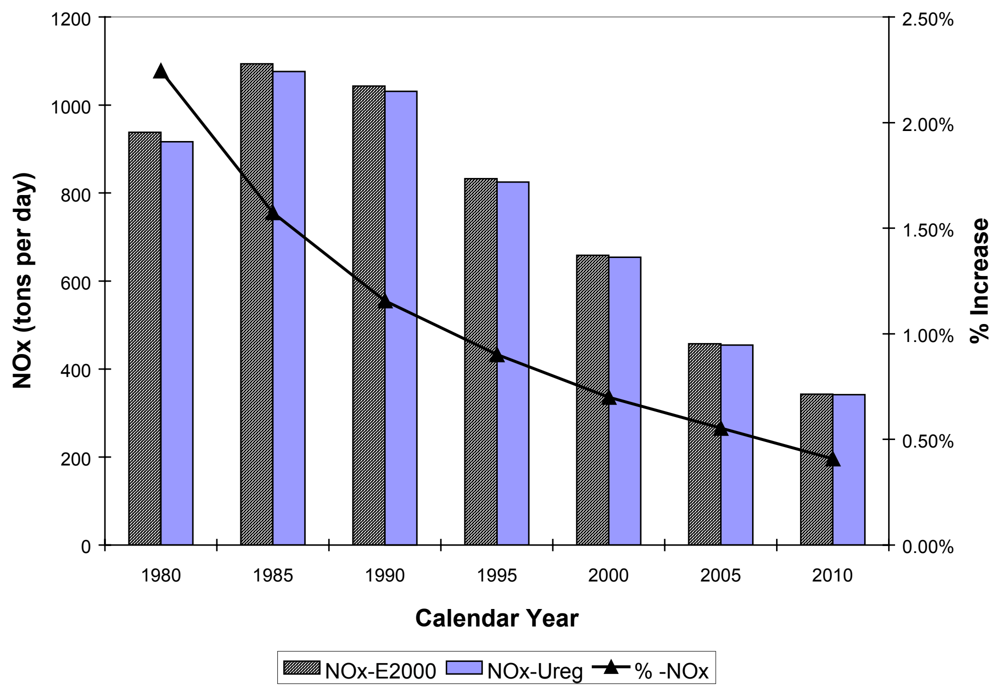
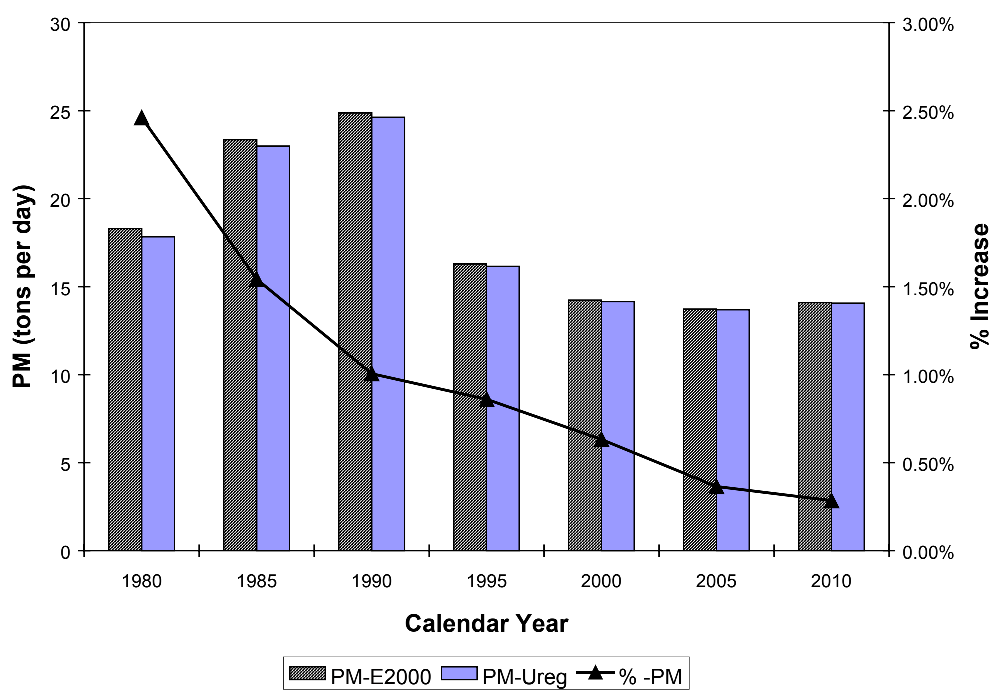


Figure 13-20 Effect of Unregistered Vehicles on Total PM Running Exhaust Emissions

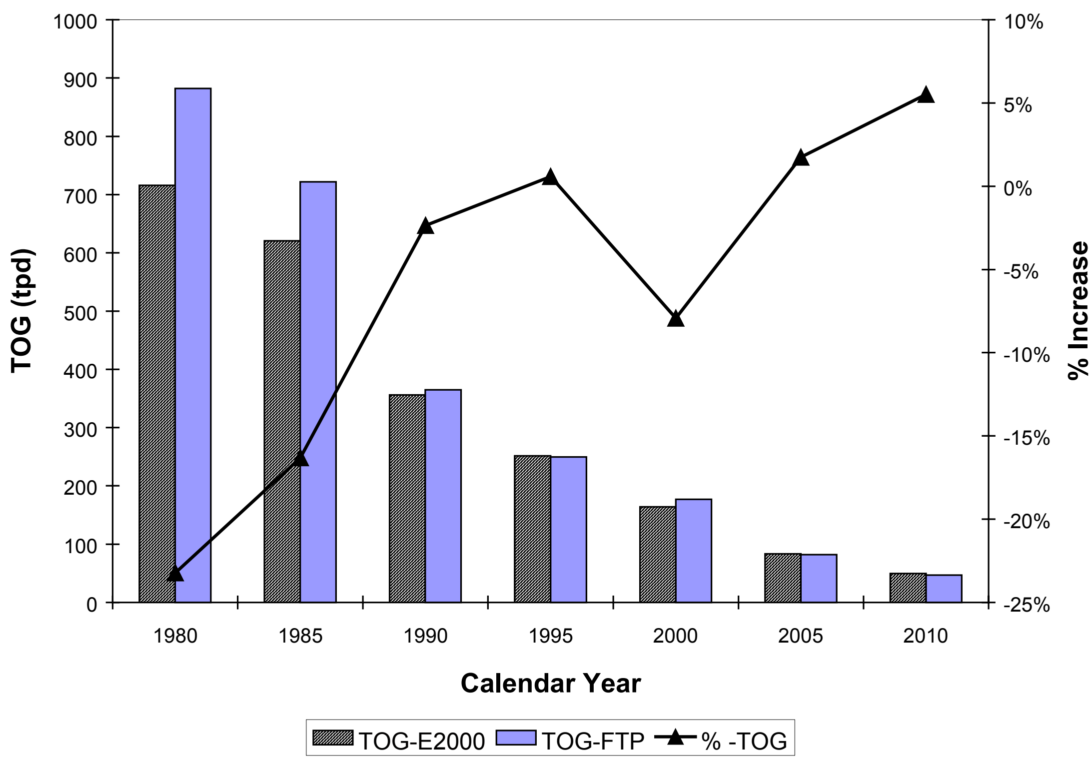


13.4 FTP Versus UC based Cycle Correction Factors

In the MVEI7G model, the basic emission rates were based on the FTP driving cycle. To adjust for more contemporary driving, these rates were adjusted to a UC basis using cycle correction factors. In EMFAC2000, the basic emission rates are on a UC basis. These rates are then adjusted with respect to speed using the new UC based cycle correction factors[2]. Figures 13-21, 13-22, 13-23, 13-24 show the percent change in TOG, CO, NOx and PM running exhaust emissions from gasoline fueled passenger cars, respectively, by changing from an FTP based model to a UC based model.

Figures 13-25, 13-26, 13-27, and 13-28 show the impact of the speed or new cycle correction factors on TOG, CO, NOx and PM emissions, respectively. The basic effect of the UC-based cycle/speed correction factors is to increase TOG emissions by 17 percent. The effect of speed/cycle correction factors on CO emissions diminishes with time, resulting in an increase of 2 percent in calendar year 2010. The speed/cycle correction factors increase NOx emissions by 3 to 5 percent.

Figure 13-21 Comparison of UC Vs FTP Factors-TOG Exhaust PC Gas



[2] Section 6.2 Cycle correction Factors

Figure 13-22 Comparison of UC Vs FTP Factors- CO Exhaust PC-gas

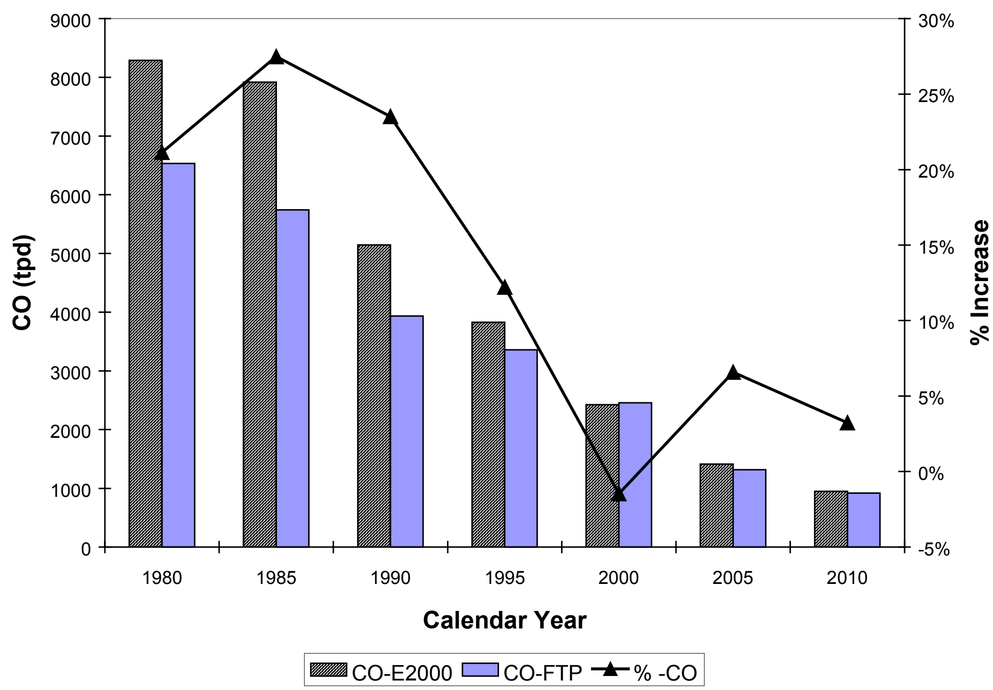


Figure 13-23 Comparison of UC Vs FTP Factors-NOx Exhaust PC gas

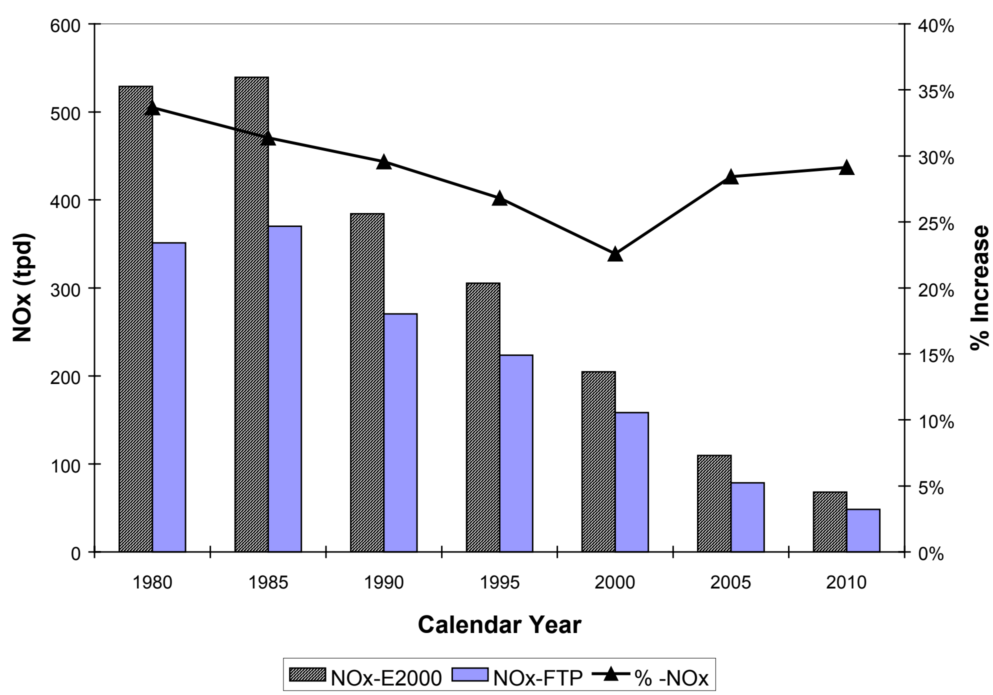


Figure 13-24 Comparison of UC Vs FTP Factors-Total Exhaust PM PC gas

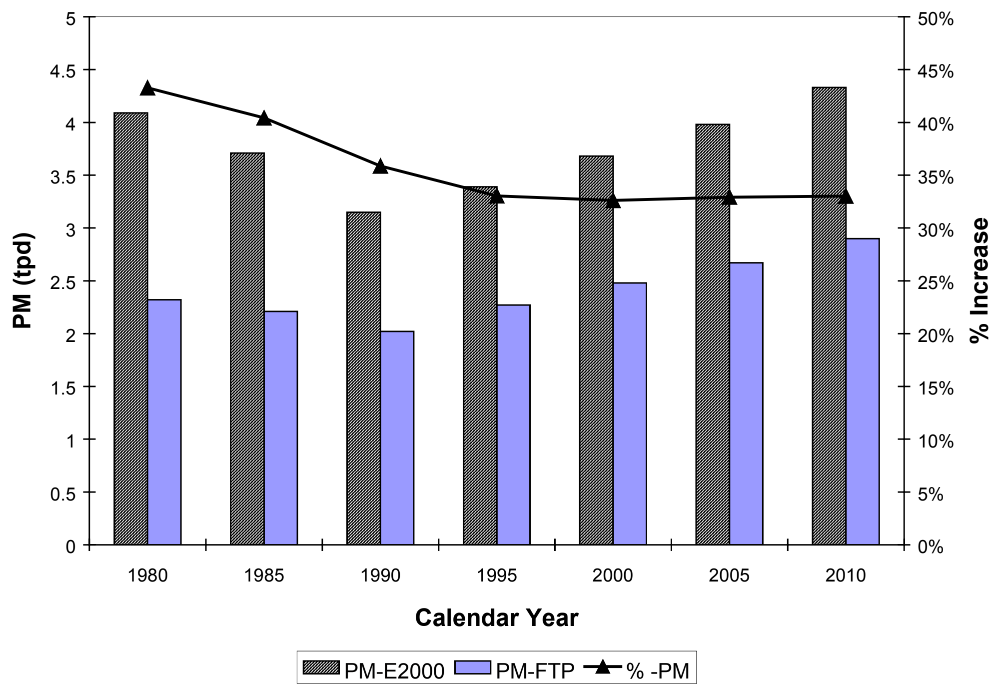


Figure 13-25 Effect of Speed on Total TOG Exhaust PC-Gas

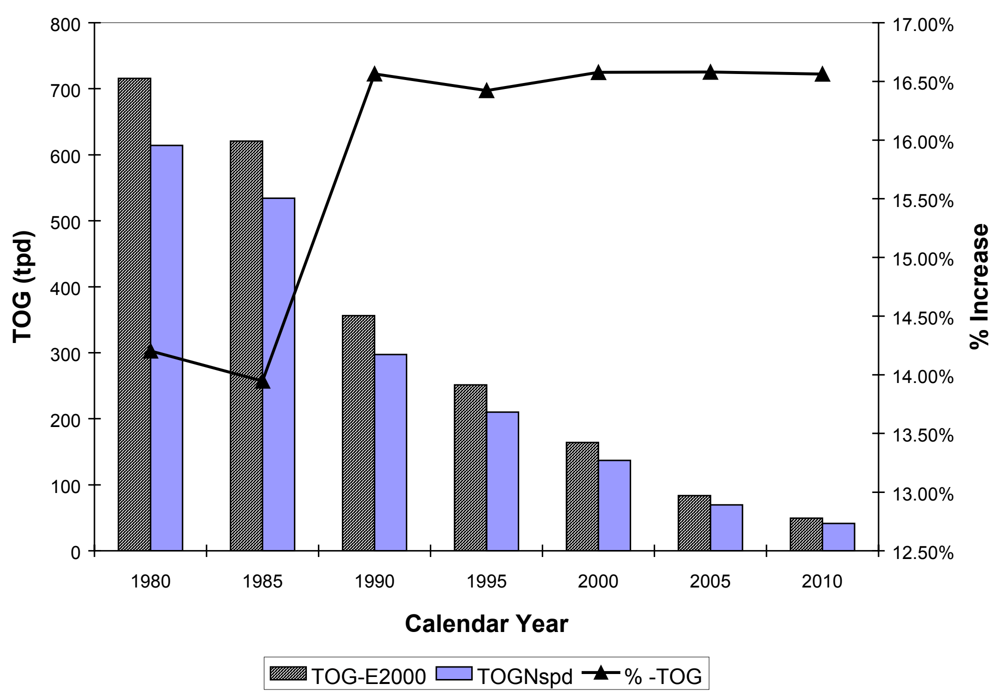


Figure 13-26 <u>Effect of Speed on Total CO Exhaust PC-Gas</u>

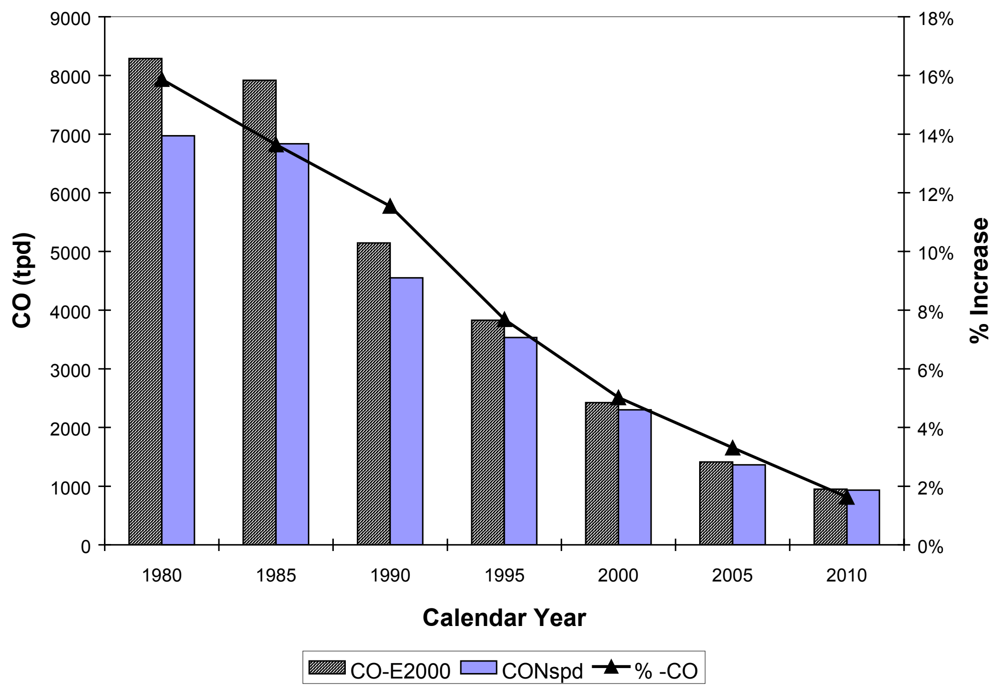


Figure 13-27 <u>Effect of Speed on Total NOx Exhaust PC-Gas</u>

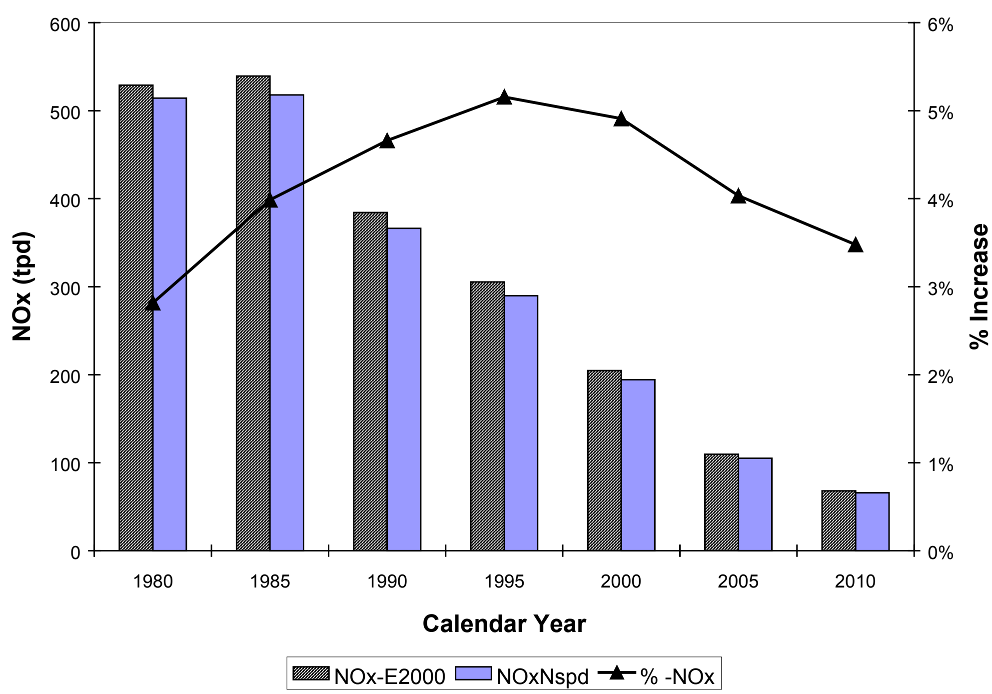
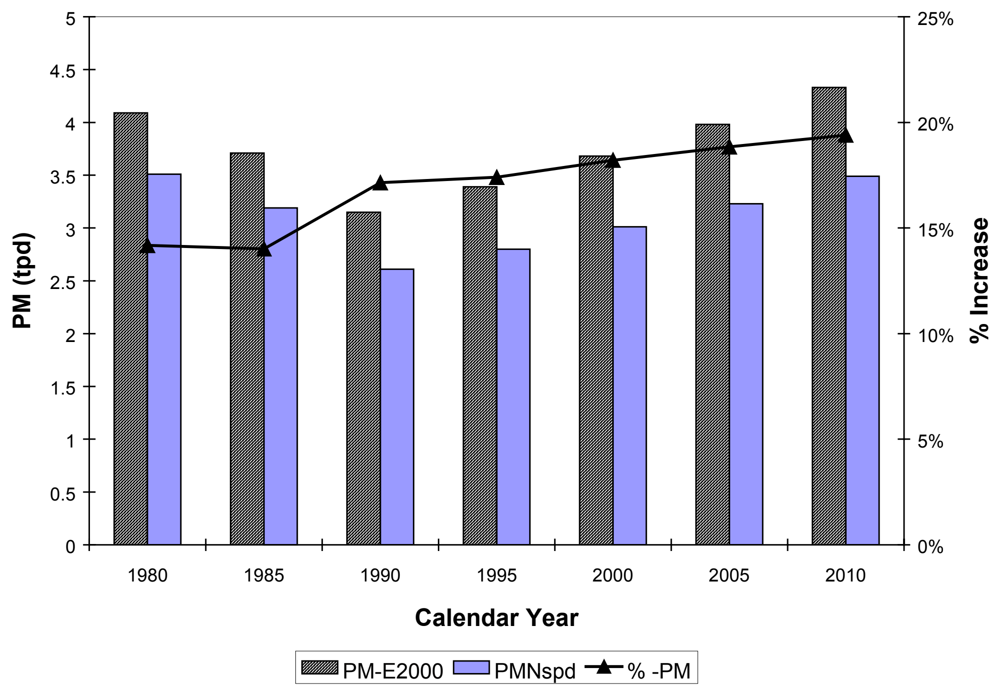


Figure 13-28 Effect of Speed on Total Exhaust PM from PC-Gas



13.5 Effect of Fuel Correction Factors

Fuel correction factors are used to model the effect of Phase 1 and Phase 2 gasoline and clean diesel fuel regulations on the motor vehicles emissions inventory[3]. The Phase 1 and Phase 2 gasoline fuel regulations limiting fuel RVP and aromatic content took effect in calendar years 1992 and 1996, respectively. Figures 13-29, 13-30, 13-31 and 13-32 show the effect of fuel correction factors impacts for TOG, CO, NOx and PM emissions, respectively.

The large NOx reduction from 1980-1990 is attributed to the early introduction of clean diesel fuel in the SCAB, which reduced emissions from diesel vehicles. Diesel vehicles certified after 1995 receive no emission reduction from the use of the cleaner fuel because these vehicles were allowed to certify using clean fuel. The NOx reductions after 1995 can be attributed to the introduction of Phase 1 and Phase 2 fuel that lowered the emissions of gasoline fueled vehicles. Figure 13-32 also shows a reduction in the PM inventory for calendar years 1985 and 1990 associated with the early introduction of clean diesel in SCAB.

An error in the fuel correction factors exists in the MVEI7G model that lead to an overestimation of the CO benefits from Phase 2 fuel. This error has been corrected in EMFAC2000. Figure 13-33 shows the impact from revising the CO fuel correction factors.

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[3] Section 6.3 Fuel Correction Factors

Figure 13-29 Effect of FCFs on Total TOG Exhaust From All Vehicles

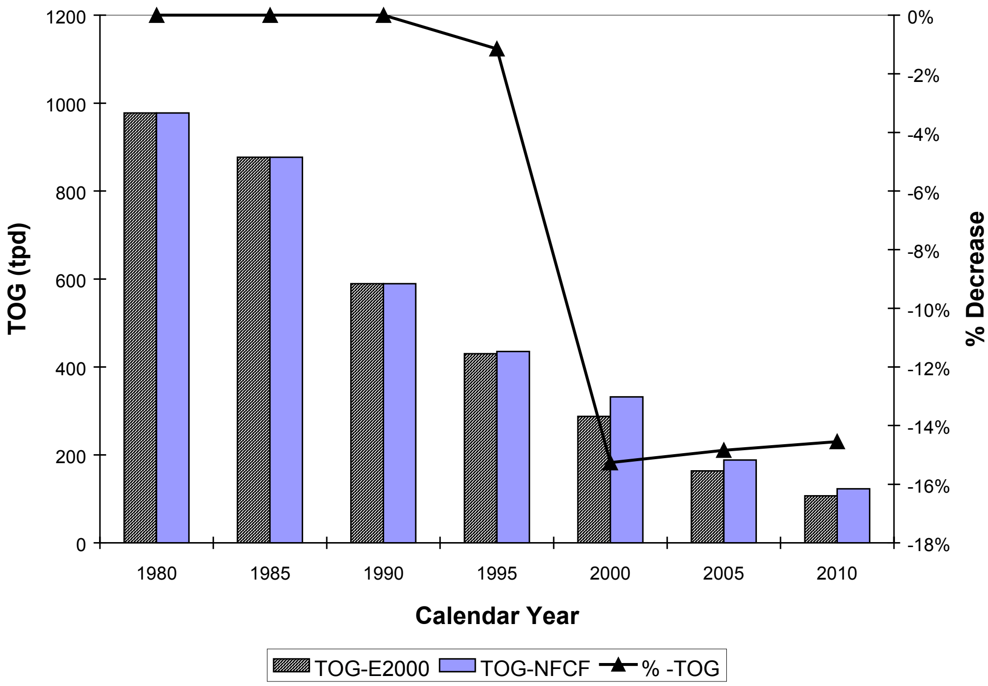


Figure 13-30 Effect of FCF on Total CO Exhaust From Vehicle

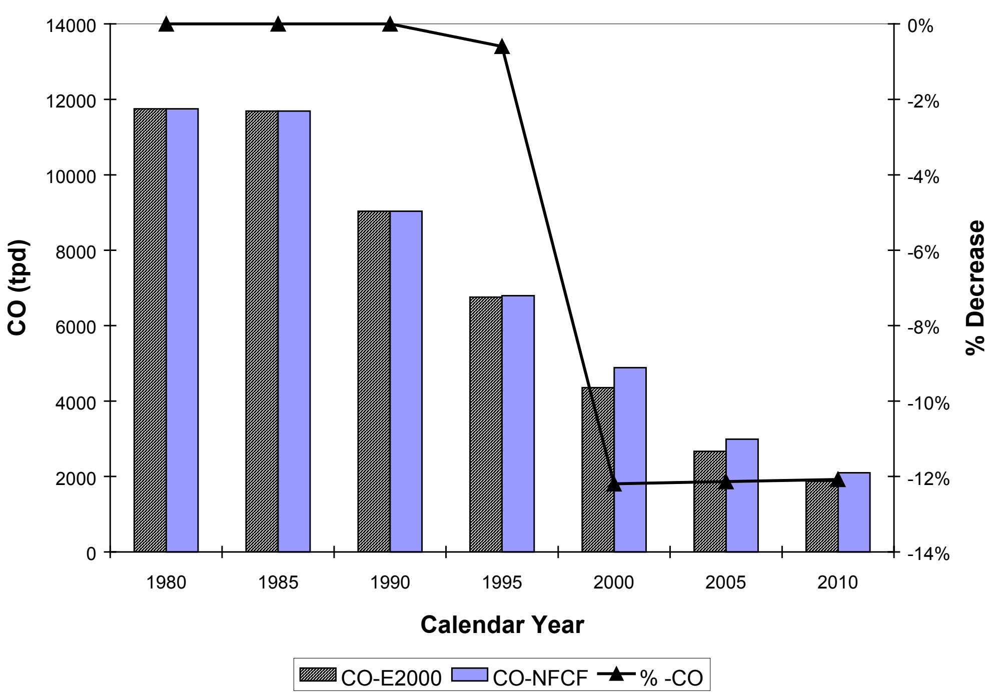


Figure 13-31 Effect of FCF on Total NOx Exhaust From Vehicles

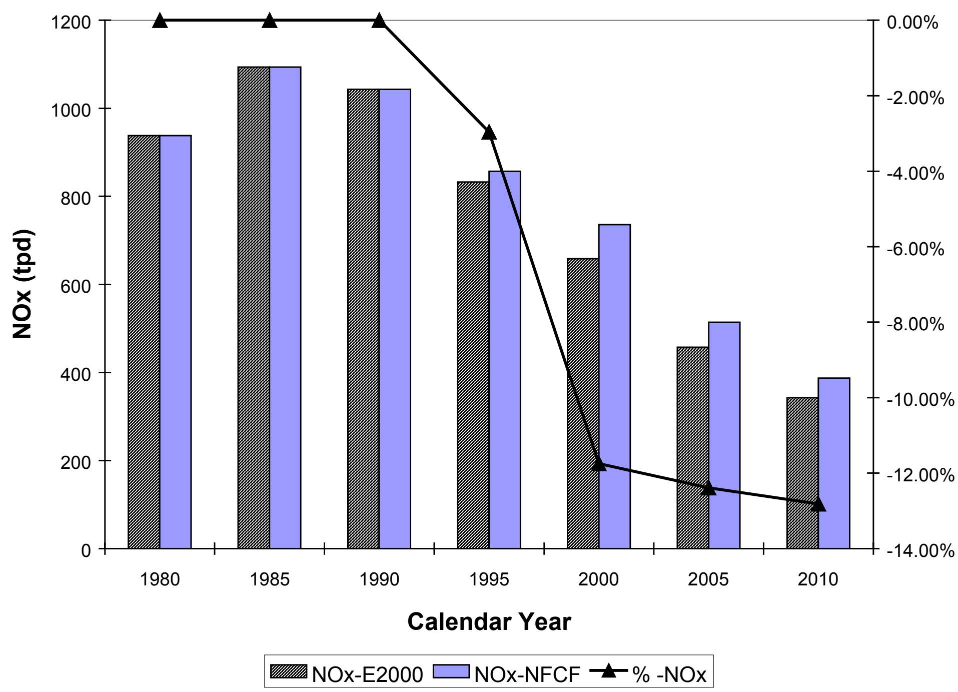


Figure 13-32 Effect of FCF on Total Exhaust PM From All Vehicles

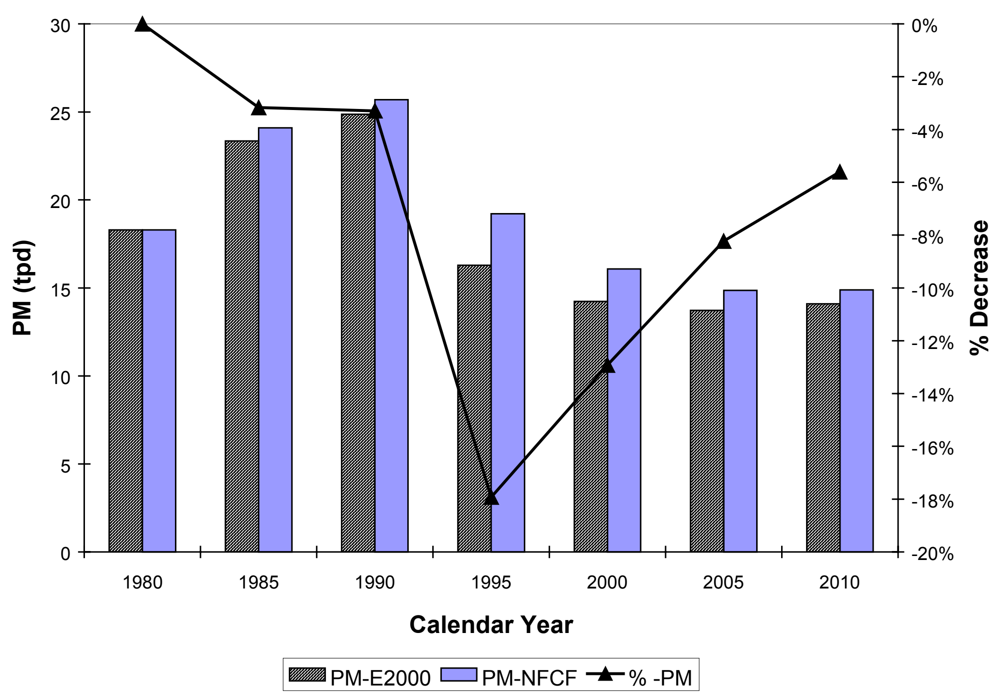
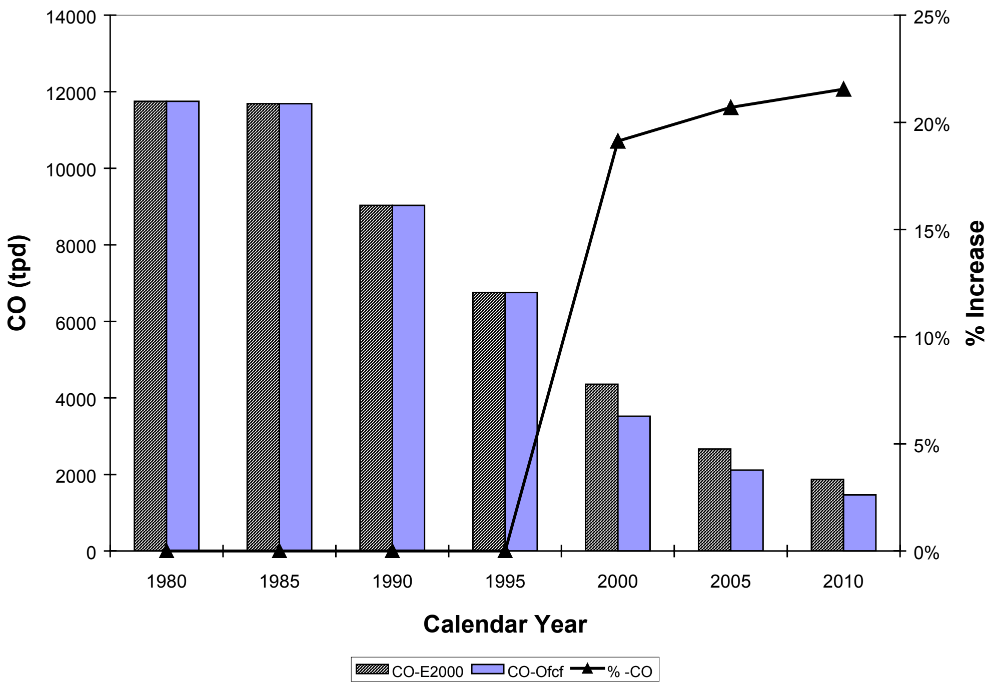


Figure 13-33 Comparison of the Old Vs. New FCFs For CO on Exhaust Emissions



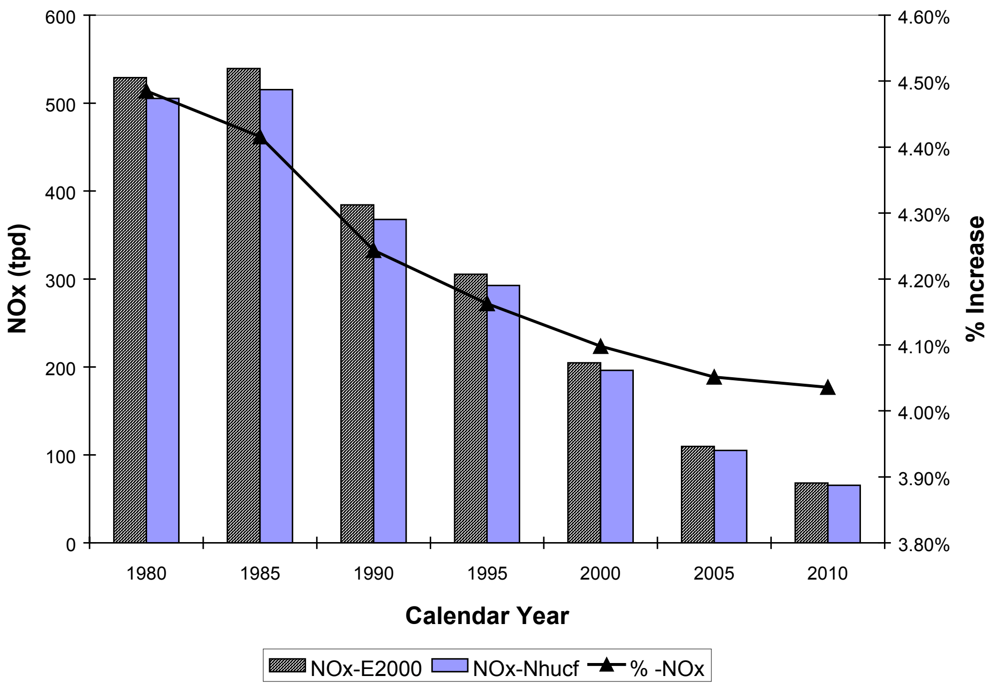
13.6 Humidity Correction Factor

During standardized emission tests such the FTP or UC, NOx emissions are adjusted to a standard humidity level of 75 grains of water per pound of dry air. However, the relative humidity levels throughout the state vary by county, month, and hour of the day. The impact of high relative humidity is to lower combustion temperatures and decrease NOx formation. Conversely, low relative humidity increases NOx formation in comparison to standardized testing.

A relative humidity correction factor was introduced in EMFAC2000 to account for the changes in the NOx basic emission rates as a function of relative humidity[4]. Figure 13-34 shows the effect of this factor on the inventory of gasoline fueled passenger cars. This factor increases the running exhaust NOx emissions by approximately 4.5 percent.

[4] Section 6.5 NOx Emission Rates and Humidity

Figure 13-34 Effect of Humidity Correction Factors on NOx Exhaust -PC gas



13.7 Effect of Air Conditioning

The effect of air conditioning usage increases the load on the engine. This increase in load results in higher running exhaust emissions. In EMFAC2000, the effects of air conditioning are modeled as a correction factor to the basic emission rates[5]. The magnitude of this correction factor is dependent on the heat index, which is a function of the ambient temperature and relative humidity.

Figure 13-35 shows that air conditioning usage increases TOG running exhaust emissions from gasoline fueled passenger cars by 2.5 to 3.8 percent. Figures 13-36 and 13-37 show that air conditioning usage increases CO and NOx emissions by 5.6 to 8.9 percent and 0.5 to 0.7 percent, respectively. Figures 13-35, 13-36 and 13-37 show that the A/C effect increases for future calendar years. This is because newer, lower emitting vehicles are effected more than current, in-use vehicles.

[5] Section 6.4 Development of Air Conditioning Emission Factors

Figure 13-35 Effect of Air Conditioning on TOG Exhaust From PC Gas

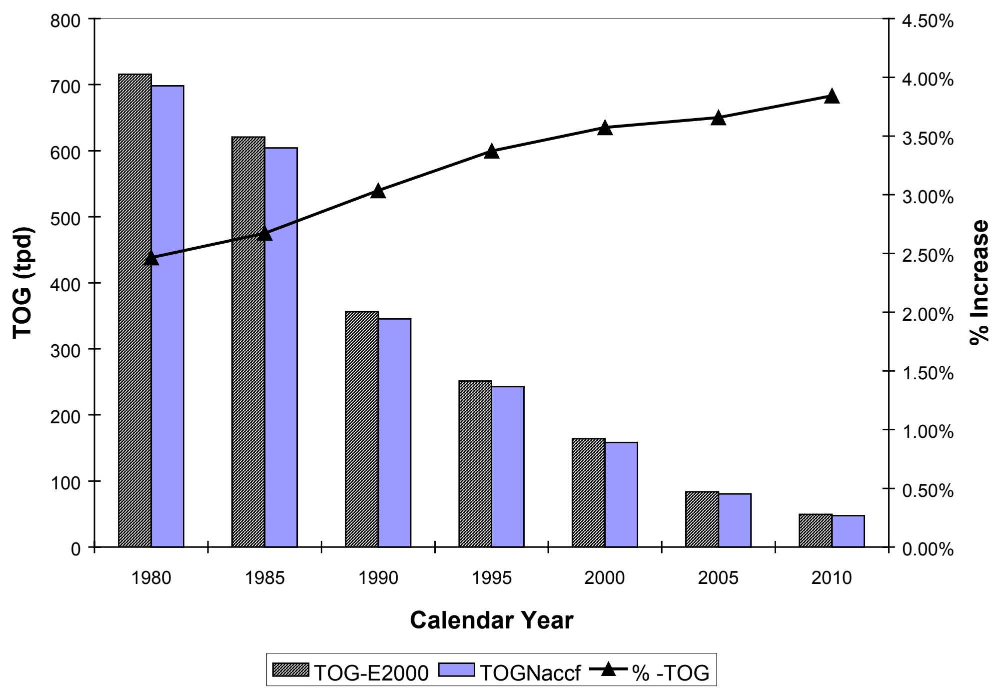


Figure 13-36 Effect of Air Conditioning on CO Exhaust from PC gas

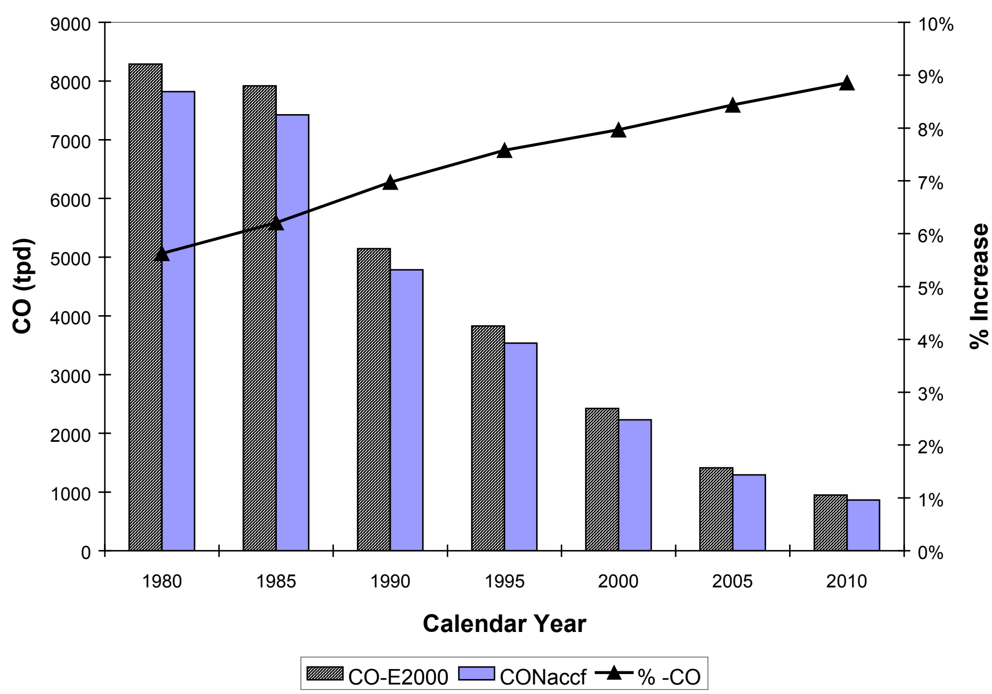
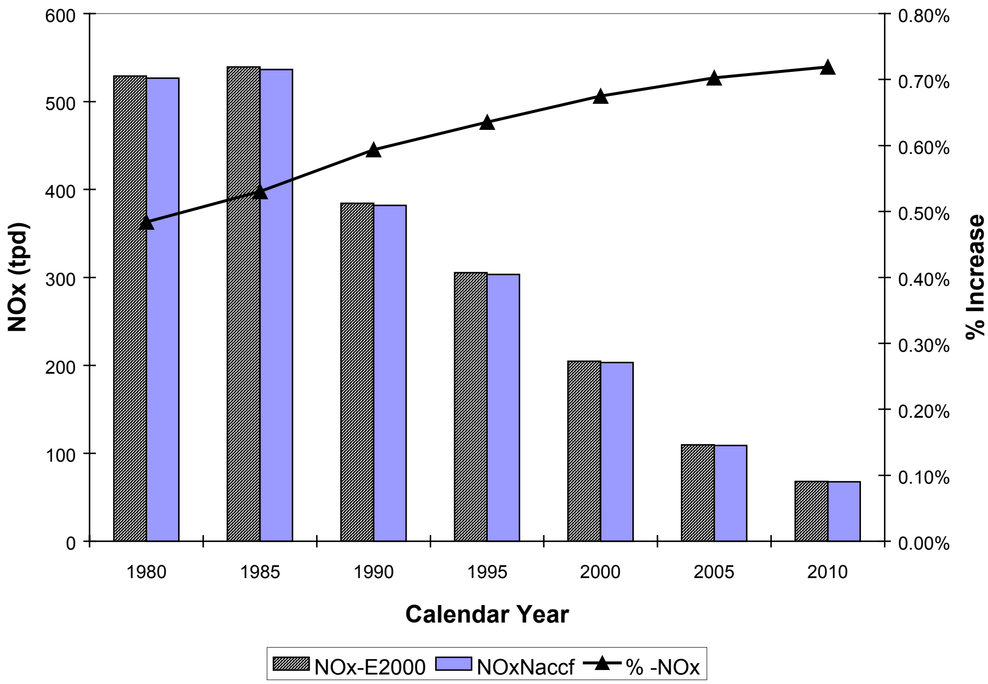


Figure 13-37 Effect of Air Conditioning on NOx Exhaust from PC gas



13.8 Effect of Liquid Leakers on Evaporative Emissions

In EMFAC2000, the percentage of the fleet that is comprised of high emitters, or liquid leakers, is based on the U.S. EPA's liquid leaker fraction[6]. The percentage of liquid leakers and their emissions contribution is important in that these vehicles may not be detected by the vehicle's on-board diagnostic (OBDII) system. The OBDII system was designed to detect vapor leaks, not liquid leaks, hence the relative emissions contribution from these vehicles is likely to increase as more stringent standards are phased in.

Figures 13-38, 13-39, 13-40 and 13-41 show the impact of liquid leakers on the diurnal, hot soak, running loss and resting loss emissions, respectively, from gasoline fueled passenger cars. The impact of liquid leakers is less (approximately 20 percent) in the early calendar years (1980-90) because the magnitude of the emissions is high. However, with the phase in of the enhanced evaporative standards and near zero standards the impact of liquid leakers increases for 1995 and later calendar years. The percentage of liquid leakers varies from 0% of the fleet of new vehicles to approximately 5% by age 15. Figures 13-38 to 13-41 show that approximately 20 to 50 percent of all evaporative emissions are attributable to liquid leakers.

[6] Section 5.1 Methodology Used in Estimating Running Loss Emissions

Figure 13-38 <u>Effect of Liquid Leakers on Diurnal Emissions from PC gas</u>

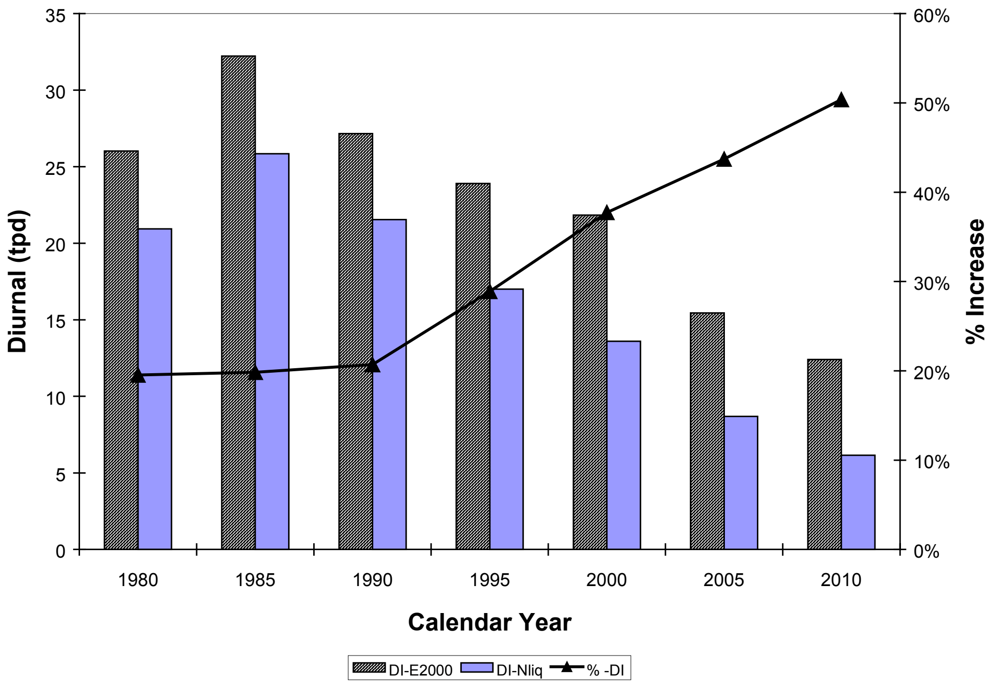


Figure 13-39 <u>Effect of Liquid Leakers on Hot Soak Emissions from PC gas</u>

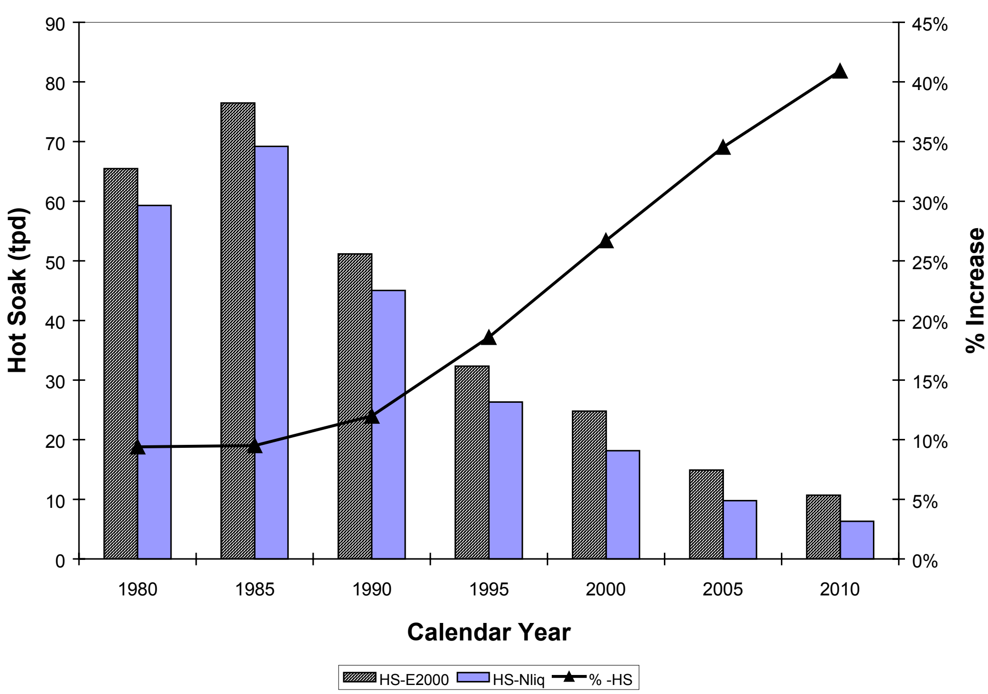


Figure 13-40 <u>**Effect of Liquid Leakers on Running Loss Emissions from PC gas**</u>

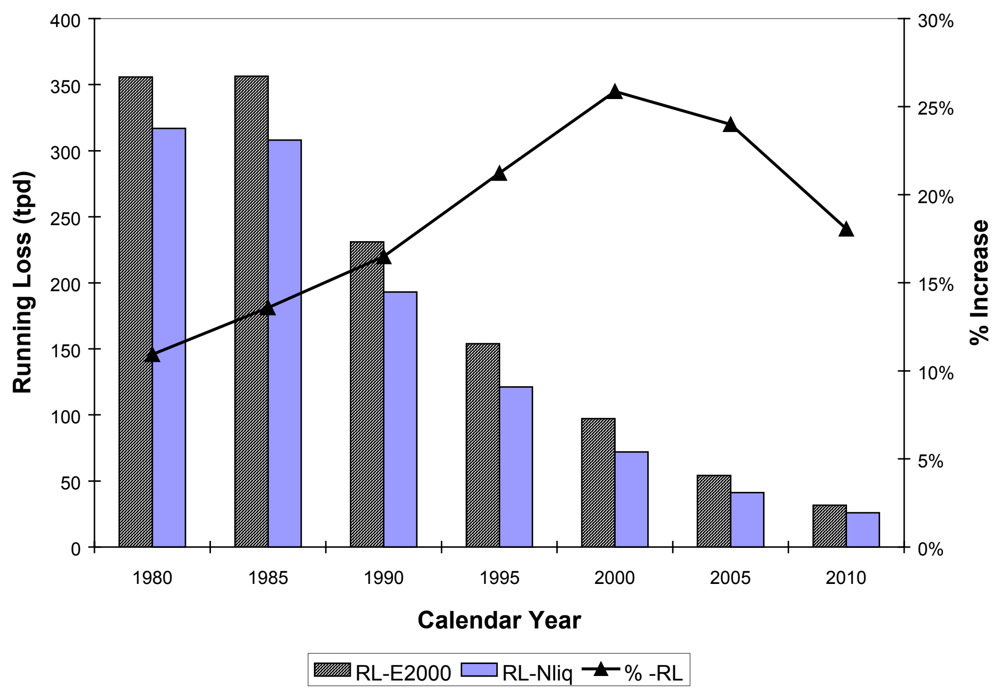
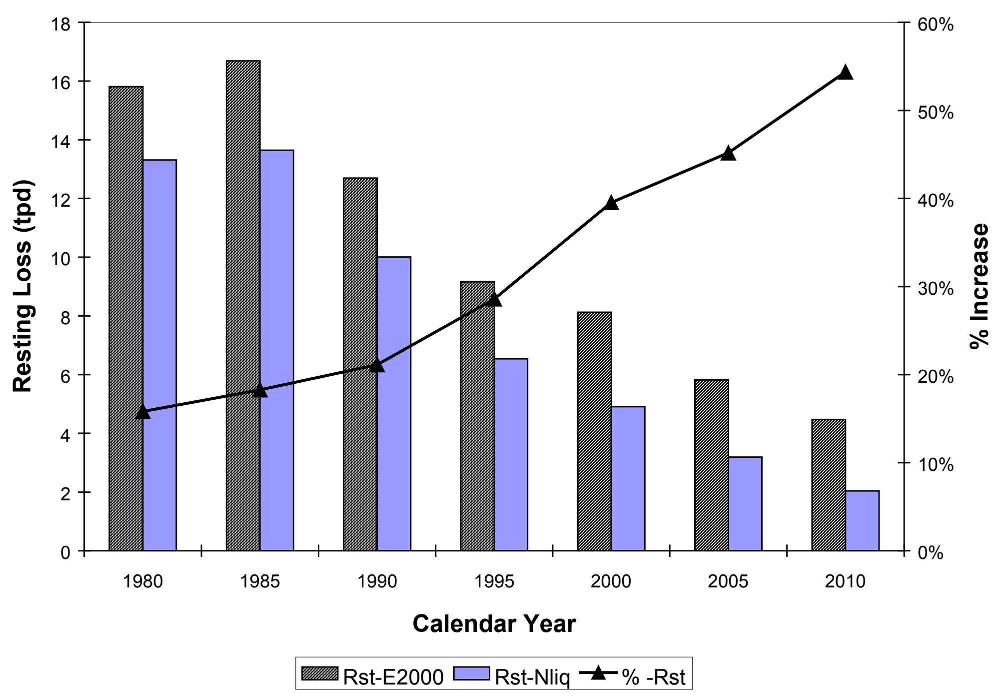


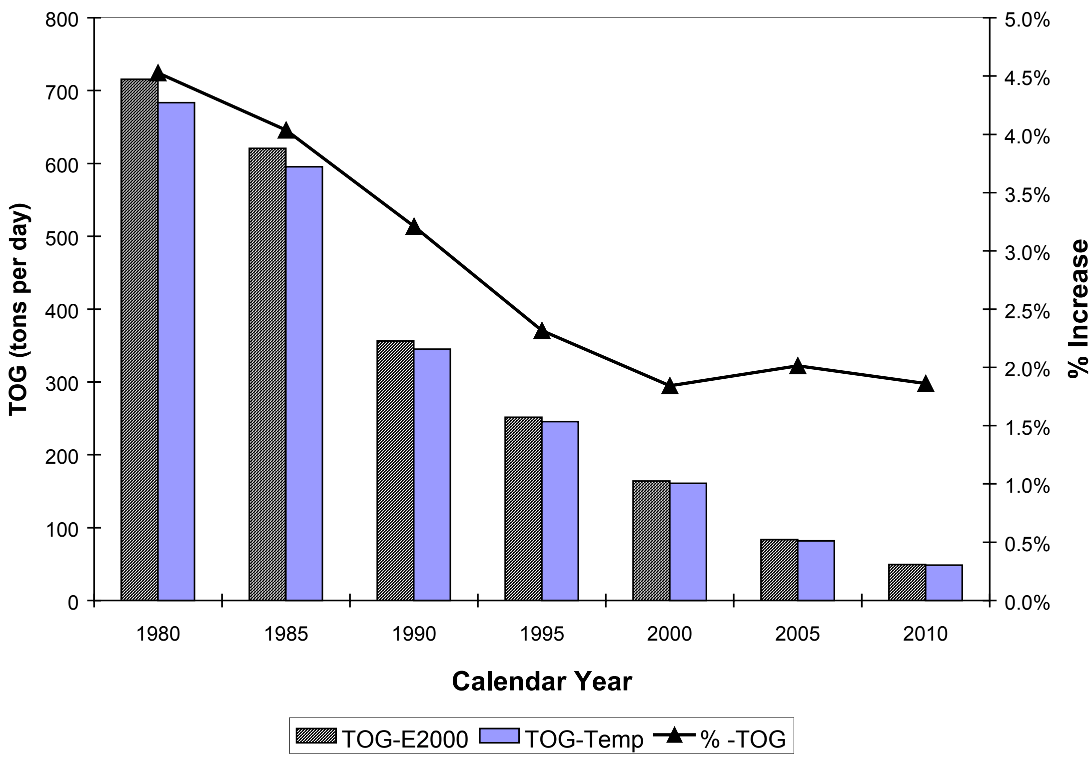
Figure 13-41 <u>**Effect of Liquid Leakers on Resting loss Emissions from PC Gas**</u>



13.9 Effect of Temperature Correction Factors

Figures 13-42, 13-43 and 13-44 show the effect of temperature corrections[7] on the running exhaust TOG, CO and NOx emissions, respectively, from gasoline fueled passenger cars. The effect of temperature correction increases emissions by 1-7% depending upon pollutant. Figures 13-45, 13-46 and 13-47 show the effect of temperature corrections on starting emissions of TOG, CO, and NOx emissions, respectively. Figures L1-L6 show that the effect of temperature corrections diminishes for future calendar years implying that emissions from newer technology vehicles are less sensitive to changes in ambient temperatures

Figure 13-42 Effect of Temperature Corrections on TOG Running Exhaust Emissions From PC-gas



[7] Section 6.1 Technology Specific Temperature Correction Factors.

Figure 13-43 <u>Effect of Temperature Corrections on CO Running Exhaust Emissions From PC-gas</u>

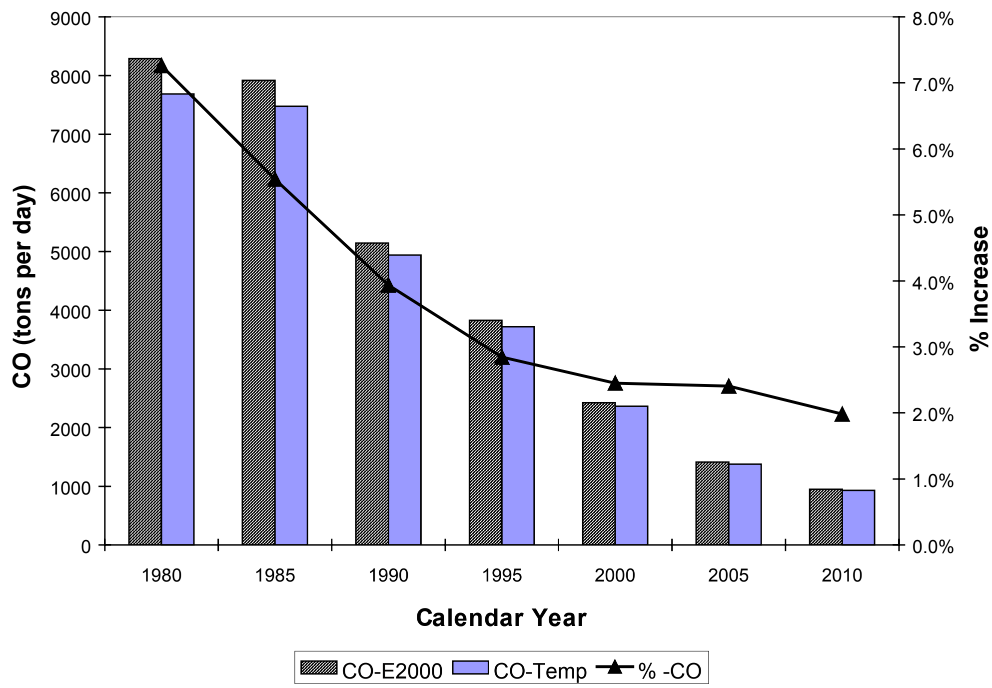


Figure 13-44 <u>Effect of Temperature Corrections on NOx Running Exhaust Emissions From PC-gas</u>

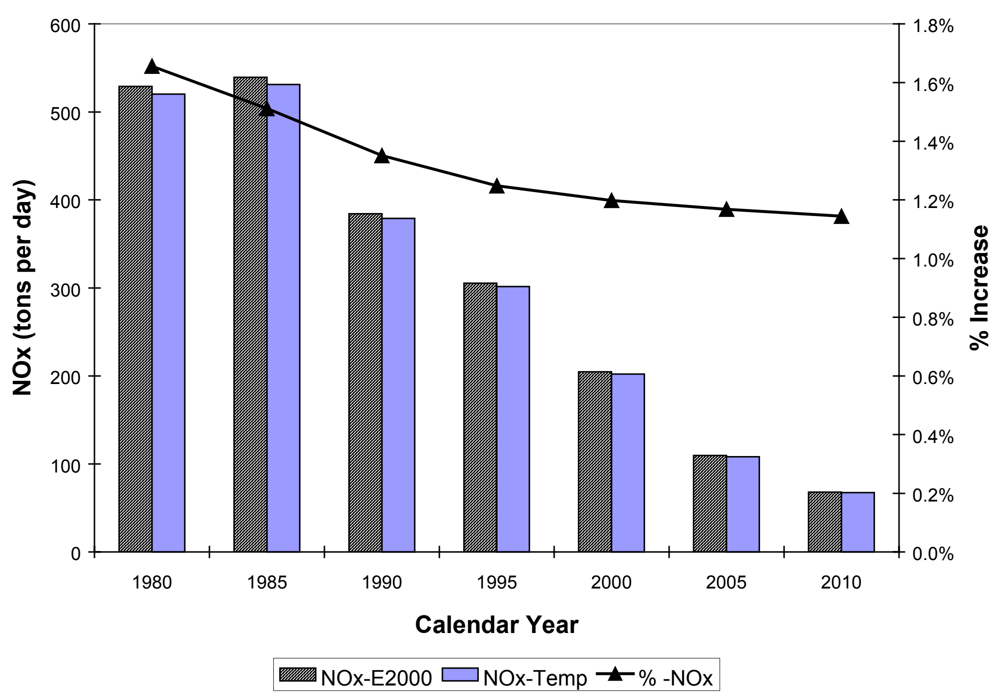


Figure 13-45 Effect of Temperature Corrections on TOG Starting Emissions From PC-gas

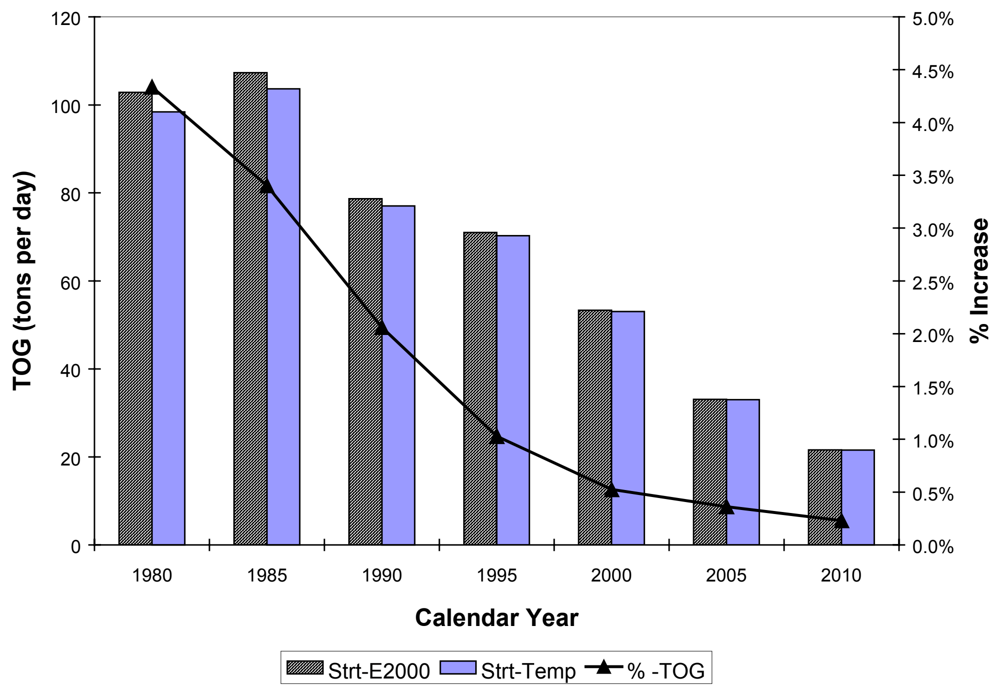


Figure 13-46 Effect of Temperature Corrections on CO Starting Emissions From PC-gas

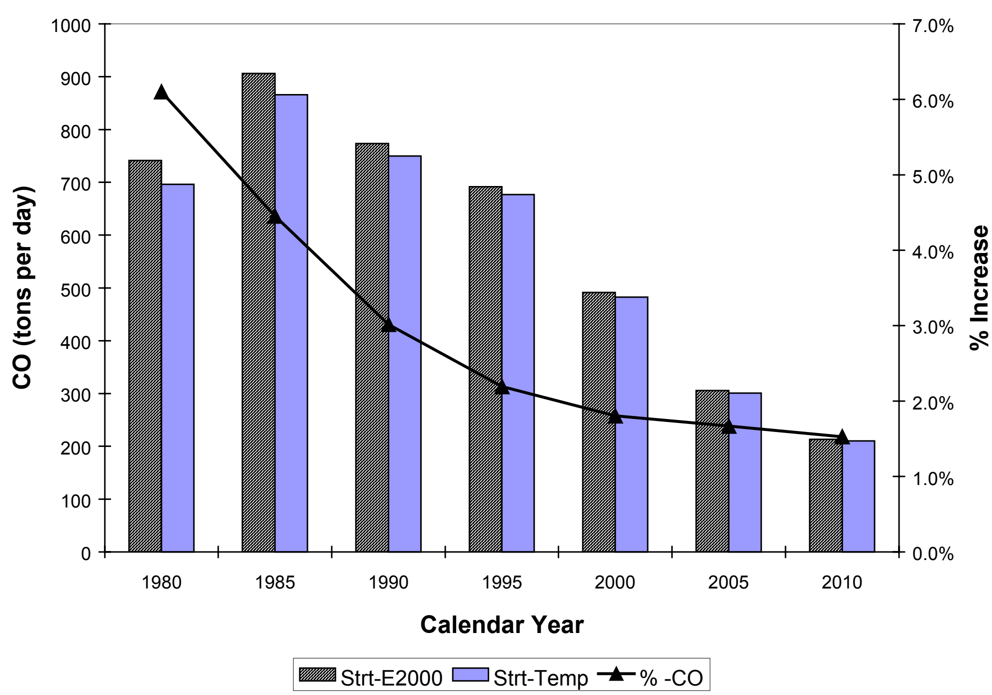
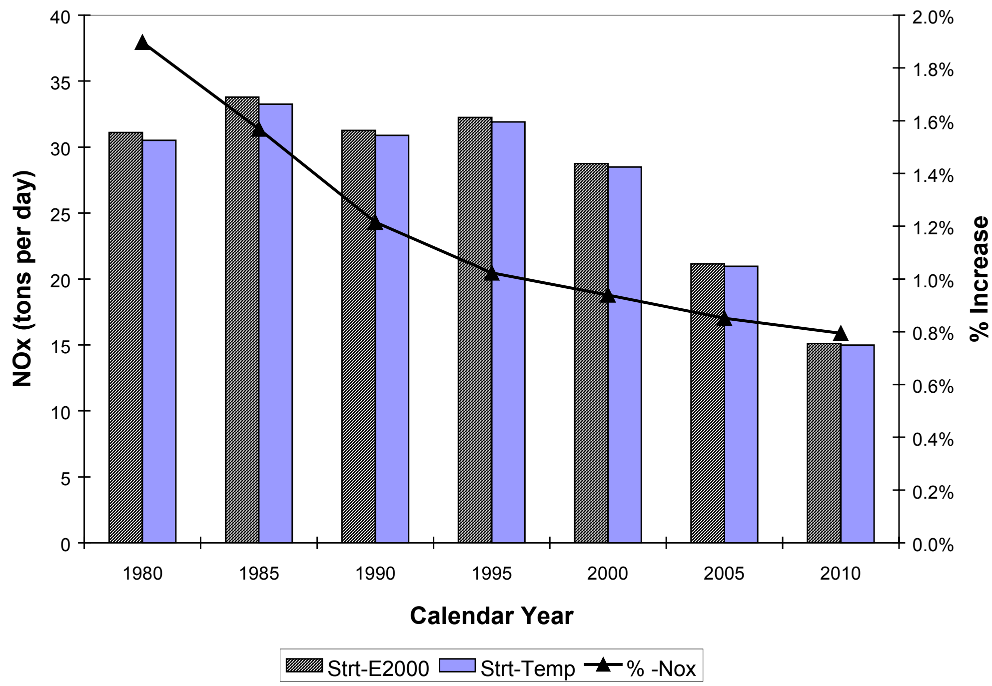


Figure 13-47 Effect of Temperature Corrections on NOx Starting Emissions From PC-gas



13.10 Effect of Inspection and Maintenance

Gasoline fueled vehicles (PCs, LDTs and MDVs) operating in the SCAB have been subject to three different I/M programs. The first program, implemented in 1984, required vehicles to be tested over a no load idle test. Failing vehicles were to be repaired within a $50 cost limit. This program was revised in 1990, requiring vehicles to be tested over both a low, and high speed idle (2500 rpm) tests. In addition, sliding repair cost limits were introduced with a $50 limit for older cars increasing to $300 for newer cars. The program was again revised in 1996[8] requiring vehicles in enhanced areas to be tested on a dynamometer using the acceleration simulation mode (ASM) test. The repair cost limit was increased to $450 for all vehicles.

The I&M program lowers vehicle deterioration by requiring failing vehicles to be repaired to acceptable levels. Figure 13-48 shows the I&M emission benefits, determined from MVEI7G, for TOG emissions from passenger cars operating in SCAB. The figure shows the emission estimates for vehicles subject to three I&M programs (1984,1990 and 1996), two I/M programs (1984 and 1990), the 1984 I/M program only, and no I/M program. The MVEI7G model predicted that the TOG emission benefits from the 1984 program, 1984 & 1990 program, and all three programs were 16%, 22 % and 24%,

[8] The enhanced I&M Program was implemented in 1998, however, it is anticipated that the full implementation, using more stringent standards to fail vehicles, will commence in the 2001 calendar year.

respectively, in 2010 compared to the no I/M baseline. Figures 13-49 and 13-50 show the I/M benefits for CO and NOx, respectively.

Figure 13-48 <u>IM Program Benefits For Total TOG From All Gasoline Vehicles - MVEI7G</u>

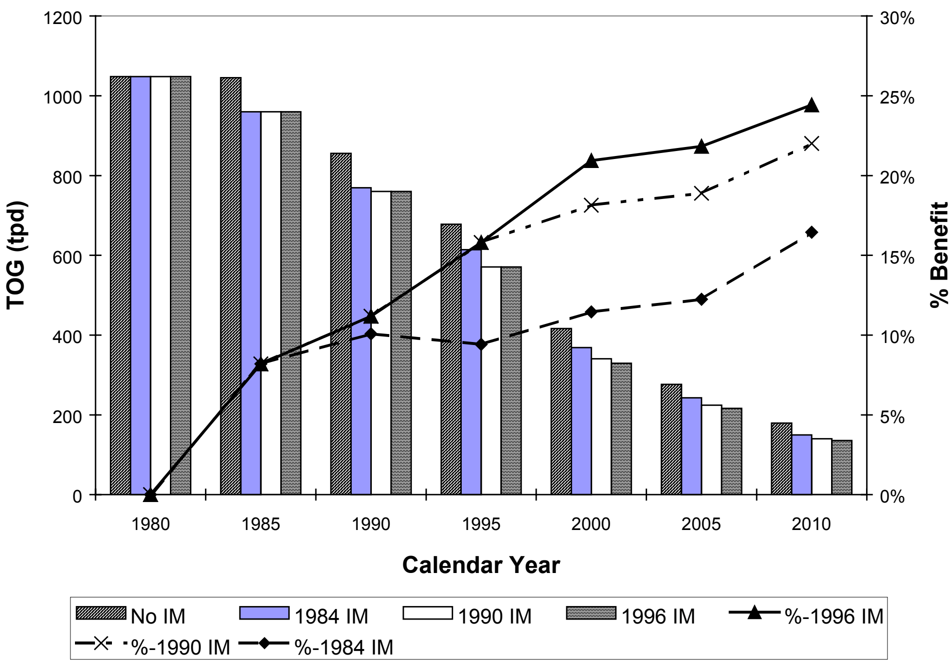


Figure 13-49 __IM Program Benefits for Total CO From All Gasoline Vehicles - MVEI7G__

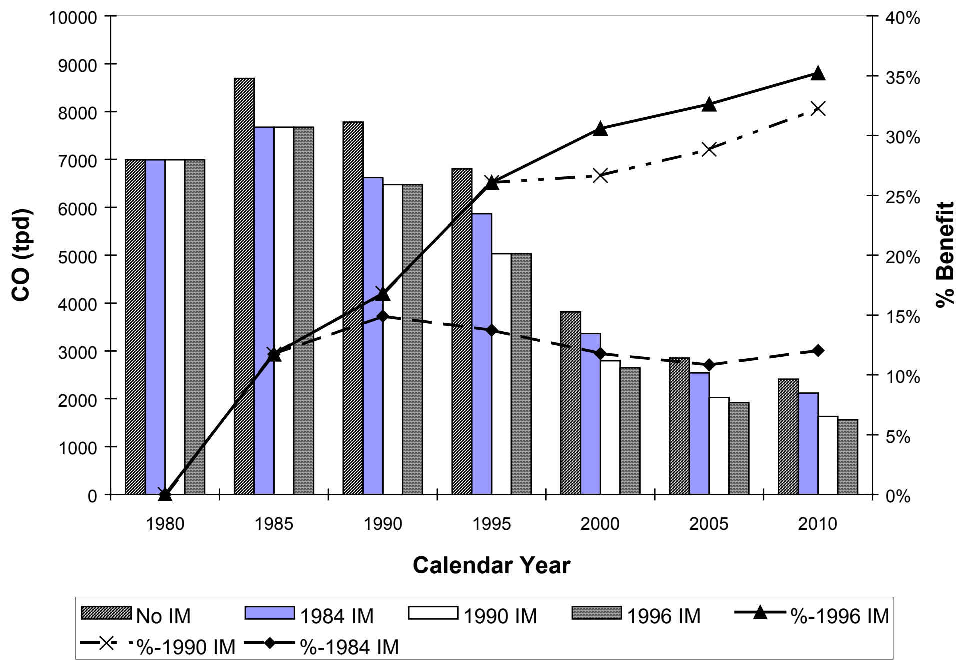
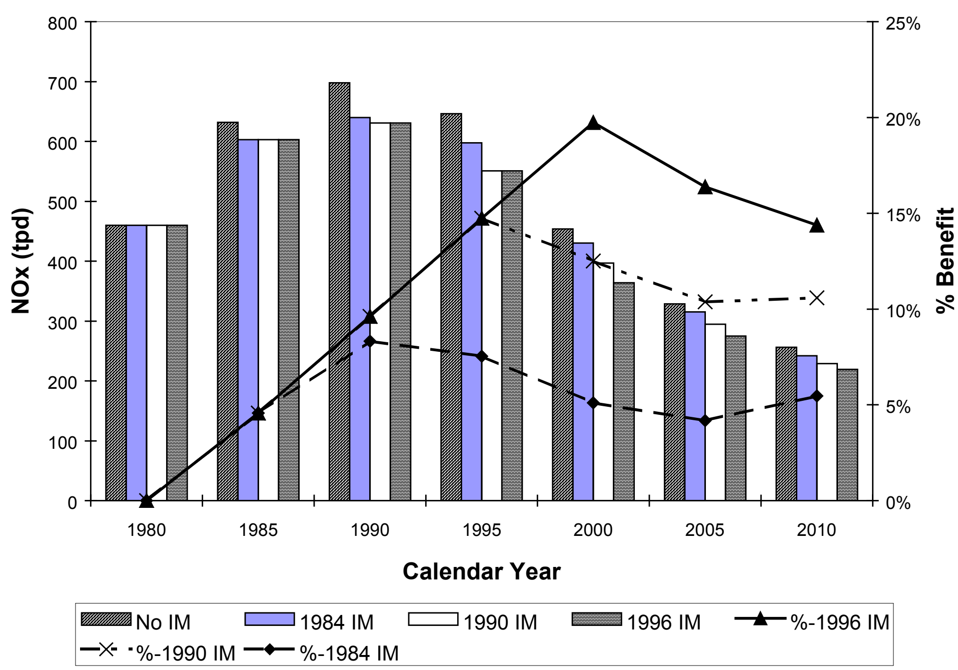


Figure 13-50 __IM Program Benefits for Total NOx From All Gasoline Vehicles - MVEI7G__



In EMFAC2000, it is assumed that the enhanced program utilizing ARB's suggested ASM cut-points will be implemented by the year 2001. Figure 13-51 shows the effect of I/M programs on total TOG (evaporative + exhaust) emissions from passenger cars in the SCAB. Figure 13-51 shows that program improvements made in the 1990 I/M program did result in further emission reductions compared to the 1984 program. The emission benefits from the 1984 and 1990 I/M programs increase for 2005 and later calendar years, due to the greater number of OBDII equipped vehicles. Figure 13-52 and 13-56 shows the emission benefits from I&M programs on the CO and NOx emissions, respectively. Table 13-1 shows the incremental tons per day reductions achieved by various I&M programs in the SCAB.

Table 13-1 Incremental Emission Reduction From Successive I&M Programs in the SCAB for Calendar Year 2010

2010	Total TOG	Incremental Redux-TOG	Total CO	Incremental Redux-CO	Total NOx	Incremental Redux-NOx
NO-IM	195.51	0.00	1642.25	0.00	135.75	0.00
1984	178.80	16.71	1478.06	164.19	117.80	17.95
1990	172.02	6.78	1420.98	57.08	114.60	3.20
Enhanced	130.30	41.72	1163.34	257.64	83.25	31.35

Figure 13-51 IM Program Benefits For Total TOG From All Gasoline Vehicles - EMFAC2000

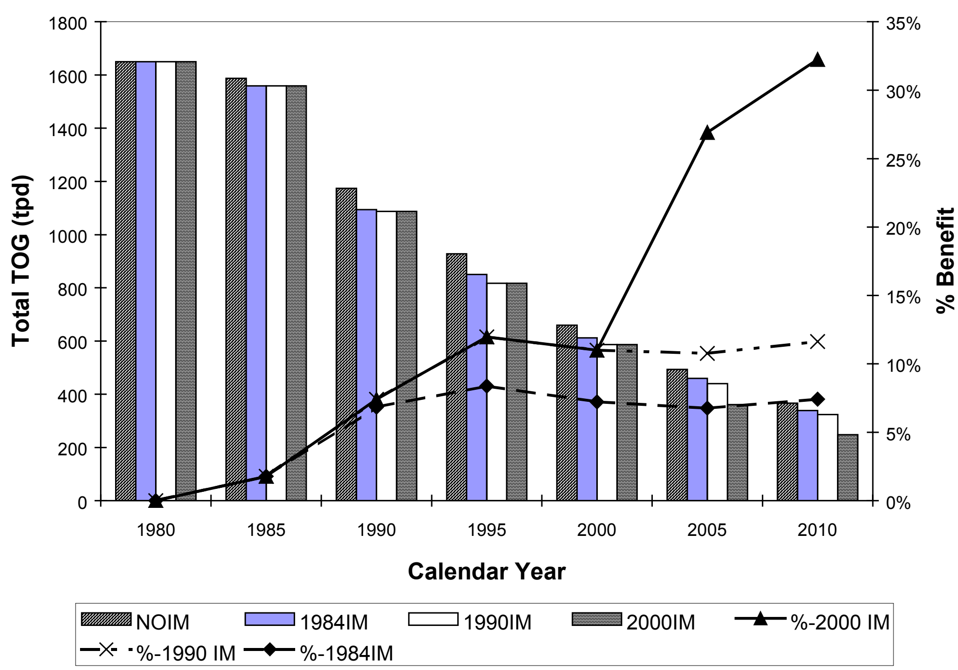


Figure 13-52 <u>IM Program Benefits for Total CO From All Gasoline Vehicles - EMFAC2000</u>

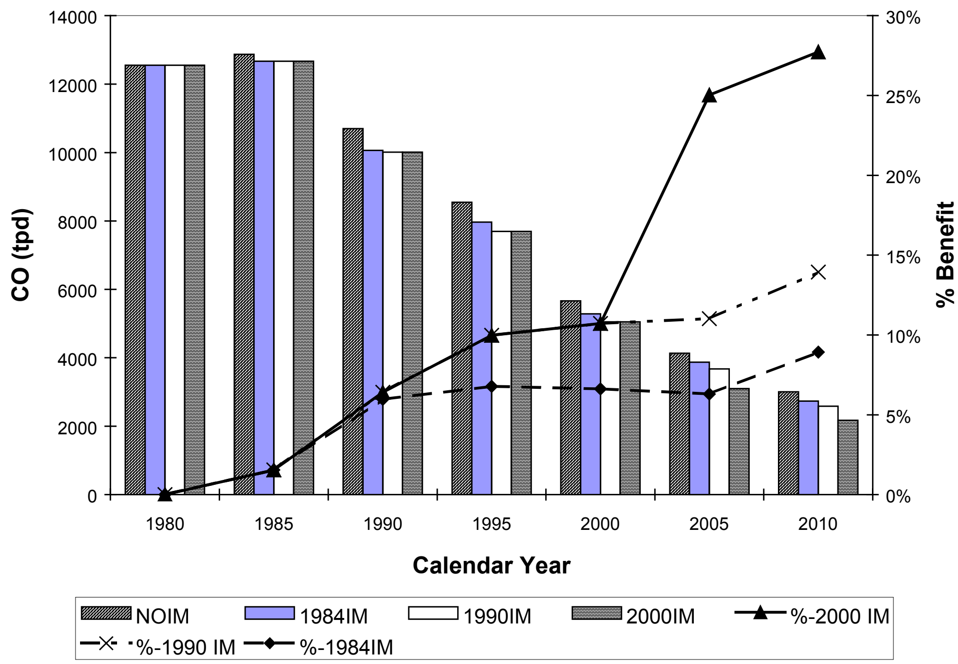
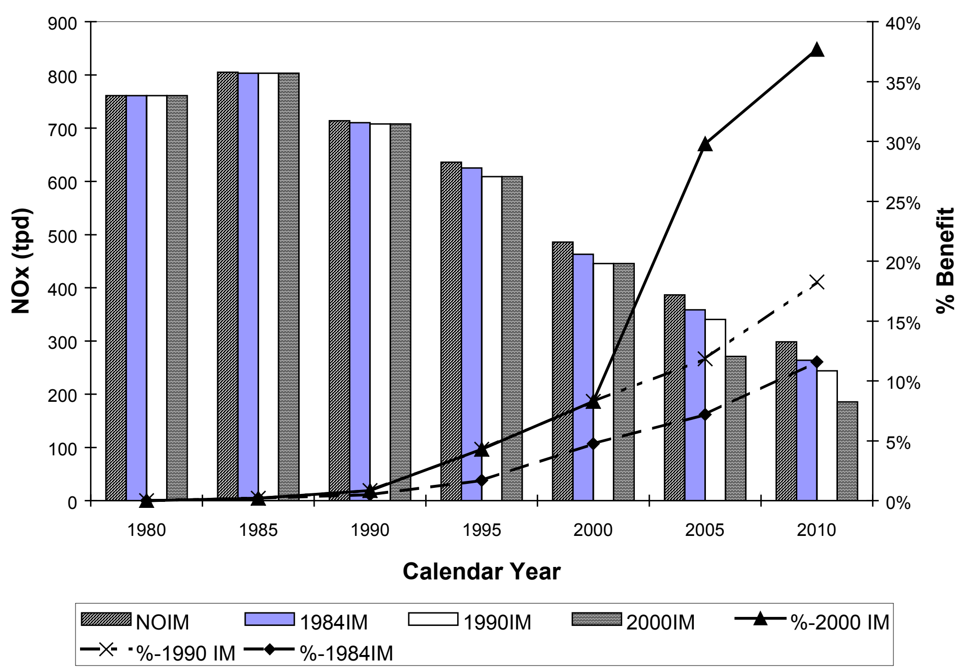


Figure 13-53 <u>IM Program Benefits for Total NOx From All Gasoline Vehicles - EMFAC2000</u>



13.11 Summation of the Incremental Increases in Emissions

Table 13-2 shows which process contributed to the overall increase in emissions relative to MVEI7G. This table shows that for calendar year 1980, the HC, CO, NOx and PM10 emissions increased by 179.5%, 232.5%, 203.9% and 51.19%, respectively, relatively to MVEI7G. The increase in HC emissions is made up a 111.8% increase basic emission rates, 2% increase due to unregistered vehicles, 20% reduction from moving to a UC based model, and a 2% increase due to AC effect. In calendar year 2000 there are no reductions associated with changes in fuel or I&M. The 2010 calendar year inventory reflects the introduction of Phase 1 and Phase 2 fuels, and implementation of I&M programs. Inclusion of these programs into the incremental effects analysis leads to differences between the compounded results and the actual differrences between the model.

Table 13-2 Quantification of the Incremental Increases for Gasoline Fueled PCs

Passenger cars-gas Tons per day	1980 HC	1980 CO	1980 NOx	1980 PM		2000 HC	2000 CO	2000 NOx	2000 PM
BERs/Vehicle age & mileage	211.84%	169.95%	125.61%	28.29%		194.01%	128.83%	94.51%	233.33%
Unregistered Vehicles	102.10%	102.23%	102.34%	102.25%		101.76%	101.51%	101.24%	100.82%
FTP to UC changes	81.15%	126.81%	150.73%	176.29%		92.65%	98.55%	129.18%	148.39%
Changes in FCFs	100.00%	100.00%	100.00%	100.00%		103.17%	127.84%	95.52%	100.00%
Air Conditioning	102.53%	105.96%	100.49%	100.00%		103.71%	108.66%	100.68%	100.00%
Humidity	100.00%	100.00%	104.70%	100.00%		100.00%	100.00%	104.27%	100.00%
Compounded	179.95%	233.46%	203.85%	50.99%		195.72%	179.03%	123.94%	349.08%
Difference from Baseline	179.55%	232.56%	203.91%	51.19%		207.15%	227.17%	143.86%	331.53%